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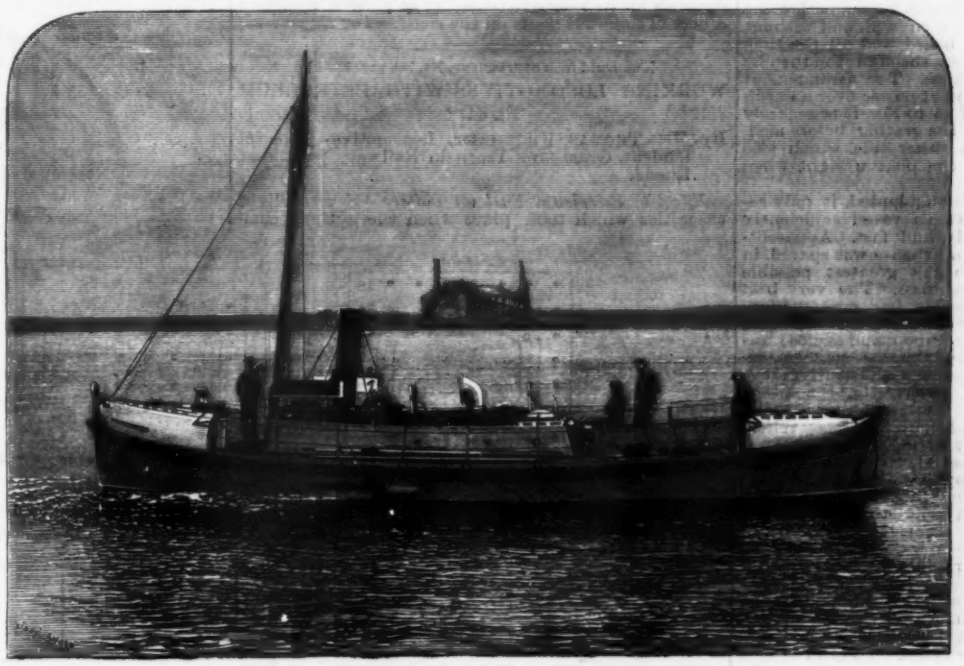
A HYDRAULIC OR JET-PROPELLED STEAM LIFEBOAT.

THE Royal National Lifeboat Institution has produced the latest novelty in ship building, in the shape of a steam lifeboat, which has recently been put through a long course of exhaustive trials, and which, after many alterations aimed at rendering her perfect, has been practically accepted as in every way complete by the Institution.

The designing of her, and the carrying to completion the alterations thought by experience to be desirable, the arranging and rearranging, and the innumerable trials, have been labors of love with Captain the Hon. H. W. Chetwynd, chief inspector of lifeboats, and with Mr. Joseph Green, of Messrs. R. & H. Green, of Blackwall, her builders. And to these two gentlemen in the first instance is due warm congratulation for the successful issue of their labor, and after them to all those who had any part in her design, construction or trials.

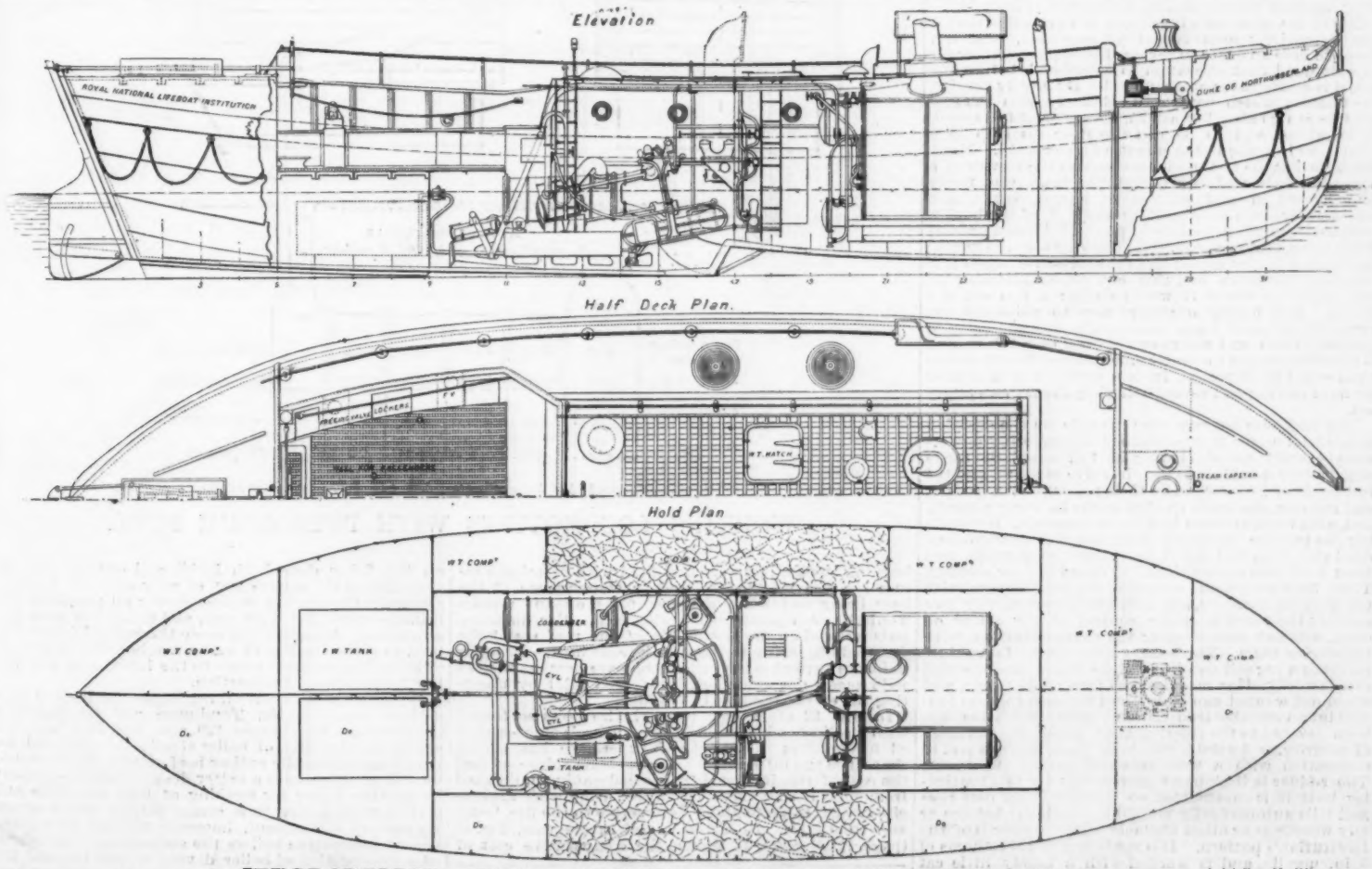
The details of this novel lifeboat, which has been named the Duke of Northumberland, after the president of the Institution, and which is to be stationed at present at Harwich, are as follows:

Length, 50 ft.; beam, moulded, 12 ft.; breadth, extreme, 14 ft. 3¾ in.; draught loaded, extreme, with three tons of coal, thirty passengers, nine crew, and full outfit, 3 ft. 3 in.; displacement at this draught, 21 tons; indicated horse power, 170. The engines are of the horizontal compound surface condensing type, with cylinders of 8½ in. and 14½ in. respectively, with a stroke of 12 in. The boiler is Thornycroft's patent tubulous pattern, having a heating surface of 606 square feet, and a grate surface of 8½ square feet. The fan engine supplying the forced draught is inverted, with a single cylinder, and runs about 1,000 revolutions per minute. The engines and boilers are each in separate water-tight compartments, both of which are efficiently ventilated, when closed at sea, by means of the forced draught fan, and by a patent cowl when natural draught alone is used. A small but powerful gun metal steam capstan is fitted on the forward hood, the engine of which is situated in a water-tight compartment below. The great peculiarity of the boat is that she is propelled by means of hydraulic power, *i. e.*, the steam engines are used for driving a turbine from which the power of propulsion is obtained. It may be said at once that this system is the only one applicable to the necessities of the case.



JET-PROPELLED STEAM LIFEBOAT DUKE OF NORTHUMBERLAND.

A paddle vessel in such a service is, of course, out of the question, as she could be so easily disabled by the slightest obstacle, and under no circumstances could she be used as a sailing vessel. A screw propeller in smooth water is the most efficient way of absorbing the power developed, but in heavy seas it would be continually out of water, and half the time practically useless. Furthermore, there is the danger of its being broken by striking the ground or against the side of a wreck, and there would be continual risk of its being fouled by rope or wreckage. In any of these cases the lifeboat herself would be of little use, for she could not be sailed with a fouled propeller dragging through the water. There are many other reasons why paddles or screws are impossible for the propulsion of lifeboats, and therefore it is that both these types of vessels—admirable as they are in their own particular spheres—were discarded, and the hydraulic principle adopted. The advantages set forth and claimed for the lifeboat are as follows: (1) The propelling power in the vessel is instantaneous; (2) no racing, loss of power, or injurious effects to the machinery, however much she rolls or pitches; (3) the vibration usually experienced in a screw or paddle boat almost disappears; (4) as the engine only runs in one direction, the wear and tear of machinery is greatly reduced, and there is no loss of time due to stopping and reversing for going astern; (5) the management of the vessel is entirely in the hands of the officer on deck; (6) there are no serious obstacles under water to interfere with



JET-PROPELLED STEAM LIFEBOAT DUKE OF NORTHUMBERLAND.

her sailing qualities, or affect her should she take the ground or run foul of ropes, etc.; (7) should anything happen to the rudder, she can be steered with the turbine alone.

The action of the turbine will be at once understood by reference to our engravings. An inlet scoop is provided on the center line of the boat of sufficient area to admit of a very large quantity of water running freely into the turbine, the entrance to the scoop being protected by means of iron bars in the shape of a grating, which will prevent the passage of anything foreign of sufficient size to interfere with the working of the turbine. The water having passed round is discharged through the valves shown at either end, and, according to the position of these valves, either through the pipes leading forward or aft, as it may be desired to propel the boat in a direction ahead or astern. The working of these valves is in the control of the commander of the boat, who can manipulate them together or separately as he wills. He can discharge through the pipe toward the bow, on the starboard side, and through that toward the stern on the port side, and so turn the boat round almost, if not quite, on her own center. He can discharge from both sides, astern, and propel his boat ahead at full speed, or he can allow a certain amount of water to pass through the pipes leading toward the stern, and so check her speed, or he can reverse altogether at his own will and without reference to any other soul on board, and all the time the engines are delivering water through the turbine at the rate of sixty tons a minute. The arrangement of inlet adopted effects a saving of power over an ordinary flush inlet in a ratio of 18 to 25. It is securely protected by—in addition to the grating before mentioned—an elm side keel on either side, which also serve the purpose of keeping the boat upright when she takes the ground.

This type of boat having been adopted, it only remained to fit the machinery into a vessel sufficiently strong, light, seaworthy, handy, and fast. Apparently neither time, nor pains, nor expense was spared in order to obtain a boat with the greatest possible strength compatible with lightness. The very best steel procurable was employed in her construction, having been submitted to the severest cold tests; indeed, so rigidly was this insisted upon, and so close was the inspection, that the hearts of the steel makers were nearly broken before material of a sufficiently excellent character was produced. The riveting is a special feature of the boat, being in excess of that usually employed in torpedo boats and similar vessels. Where a torpedo boat has double reveting, the lifeboat is triple riveted, and there is no single-riveted seam from stem to stern, either inboard or in the hull of the Duke of Northumberland. The strength and seaworthiness are still further amplified by a complete system of subdivision of longitudinal and transverse water-tight bulkheads, giving in all fifteen water-tight compartments, each of which can be rapidly drained by bilge pumps and steam ejectors.

Great attention was paid to insure stability, and several tests were made, one being of a highly practical nature. All the weights being placed on board, a heavy parbuckle was passed around the vessel. The end of this was fastened to a powerful steam crane furnished with a dynamometer, and the boat was then inclined until she lay completely on her beam ends. In this position lack of stability would have been apparent by her turning entirely over, which she was free to do, but so confident were the designers of the accuracy of their calculations—which showed righting powers up to 110°—that two members of the firm remained on board during the whole of the experiment. The final trials—official—to prove the boat's great handiness in maneuvering, sea qualities, speed, etc., took place on the river between Blackwall and Gravesend on July 24.

One of the greatest advantages of the boat is that it can be entirely maneuvered by one man, who has never to give an order to reverse his engines, and never to wait until that operation is completed before the vessel is again under his command. By merely turning the handles which control the delivery from the turbine he can go ahead or astern, slowly or at full speed, as he wishes, and as he can also steer his ship to a nicety, he is quite independent of a coxswain. Many times during the trial under notice was the service of a coxswain dispensed with, and the boat was freely maneuvered in and out amidst barges, boats, and steamers by turbine alone. The speed of the boat is sufficiently good, as under ordinary circumstances, and when not unduly pressed, she can do a good nine knots; but with a heavy forced draught pressure, when it is necessary to drive her, this can be considerably increased, as no doubt it would during a run out to a wreck. It is hardly necessary here to point out the great advantage the boat possesses in that she brings a perfectly fresh and unexhausted crew to a wreck, and is thereby enabled to render much more efficient service than could be expected from a crew much exhausted by hard rowing and severe buffeting about in an angry sea.

The boat was not run over the mile on the occasion of her trial under notice, but her maneuvering powers were severely tested. Going at full speed, she made with rudder a half circle in thirty-five seconds, and the full circle in fifty seconds. Going slowly with rudder and turbine, she made the full circle in forty seconds, and with turbine alone in fifty-two seconds. By working the turbine levers on deck, she was brought to a dead stop from full speed in thirty-two seconds, and from dead stop she attained full speed in four seconds. These tests were made several times, and always with the greatest accuracy, and they prove conclusively how entirely the vessel is under control of the officer on deck, without necessitating any communication with the engine room. The boat is also rigged for sailing, carrying a lug sail and jib, and no doubt can be sailed satisfactorily. Her mast is fitted into a tabernacle, and when not wanted can be lowered between the two funnels into a suitable iron crutch. Much attention has been devoted to the steering gear, which, for additional security, is twofold, viz., yoke lines, and a wheel in connection with a well arranged patent screw gear. The rudder is Hickman's patent, but for this particular boat it is constructed so that the lower part rises and falls automatically should it touch the bottom or any wreckage or other obstacle. The anchor is of the Institution's pattern. It is made fast to 120 fathoms of 5 in. manila, and is worked with a handy little cat davit.

Accommodation for a shipwrecked crew is provided in a spacious well just abaft the engine room, which will carry about thirty passengers, and around which a comfortable and sheltered seat runs. This well is fitted with large valves, through which any water taken on board is freely discharged; and numerous scupper holes, with non-return flaps, are also fitted. The seat running round is formed of teak lockers, in which much can be stowed. Under the deck of the well are two tanks, capable of holding water equal in weight to that of a shipwrecked crew; and in order that the trim of the boat may be kept constant, these tanks are kept full when running out to a wreck, and only pumped out when the crew to be saved is on board. The remainder of the top of the boat is covered with "corticine," which gives a firm grip to the foot, and greatly reduces the danger of being thrown by heavy rolling.

The Royal National Lifeboat Institution was established in 1824, and from then until the end of 1889 it has the magnificent total of 34,670 lives saved placed to its credit, a fact which entitles it to the heartiest support from every soul in the three kingdoms who is connected, directly or indirectly, with those who go down to the sea in ships, and which ought to establish its claim to that voluntary contribution on which it depends for its very existence. It at present possesses a fleet of some 293 boats on the coast.—*The Engineer.*

[Continued from Supplement, No. 769, page 12286.]

WORKING LOCOMOTIVES WITH PETROLEUM FUEL.*

By Mr. Thomas Urquhart, Locomotive Superintendent, Grazi and Tsaritsin Railway, Southeast Russia.

Effect of Petroleum Fuel on Boilers.—Several slight casualties which took place when the author's coal-burning locomotives were first fired with petroleum refuse led him to imagine that in consequence of the heat being so intense the cost for incessant repairs would be even greater than with coal. For instance, nuts screwed on the lower ends of the roof stay bolts dropped off, owing to the very intense heat. In order to insure perfect safety, these bolts are now made with solid heads, not welded on, but forged solid by upsetting the end of the bolt in forging.

In Fig. 32 are shown the Belpaire bolts so forged with a solid head, as used in the author's eight-wheeled locomotives. Five years' experience has shown that since the introduction of petroleum refuse as fuel the cost of repairs has been considerably diminished from what it was previously when firing with anthracite, which is particularly destructive to the fire boxes and tube ends. In Table V. and in diagram, Fig. 30 (page 12285 *ante*), is shown the comparative cost of engine and tender repairs per thousand axle miles of trucks, wagons, or carriages (not locomotives) during the twelve years 1876 to 1887, forming part of Table VI. and Fig. 31, and it is seen that in 1882, the last year in which coal was used alone, the repairs cost 4·7 shillings, while in 1887, when burning wholly petroleum refuse, the cost had fallen to 2·3 shillings, being a reduction of 51 per cent. The petroleum flame produces in reality no more detrimental effect on the fire box and tubes than a wood flame, owing to the protection afforded to the more important parts by the firebrick lining. Moreover, petroleum refuse does not contain any sulphur, which is so prevalent in all coals and so injurious to the metal of the fire box and tubes.

Plating up of Fire Door.—Since the discussion of his former paper the author has availed himself of a suggestion then made by Mr. Joseph Tomlinson (Proceedings 1884, page 299), that in a locomotive burning petroleum there need be no firing door whatever to the furnace.

Although adequate reasons were given at the time why it would not then have been expedient to do away with the firing door, Fig. 33, yet, now that the petroleum refuse promises to be the fuel of the future for many years to come, the author has already plated

Fig. 32.

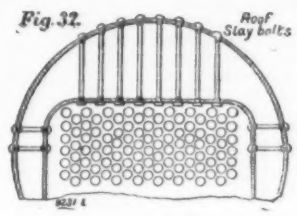


Fig. 33.

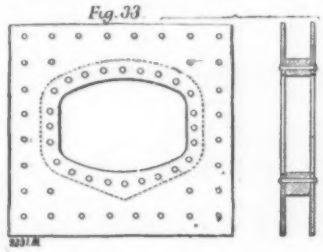


Fig. 34.

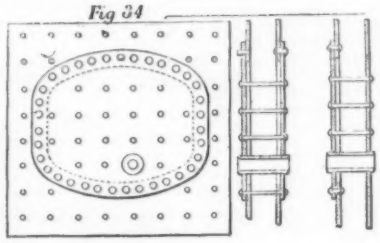


Fig. 35.

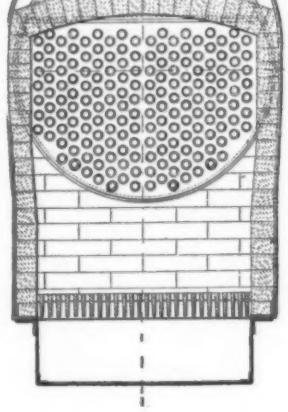


Fig. 36.

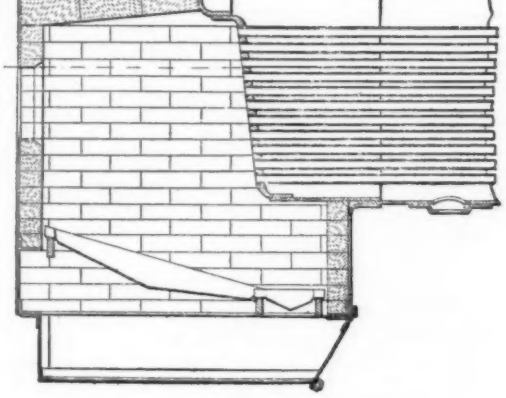
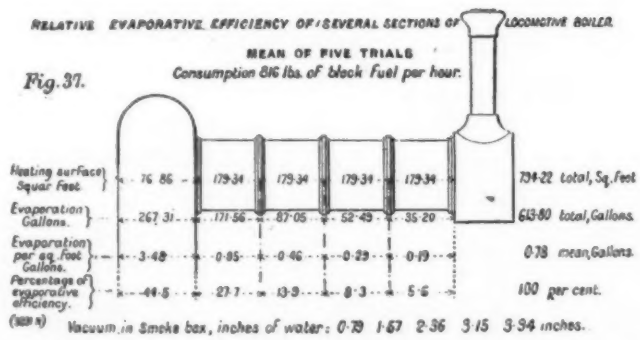


Fig. 37.



WORKING LOCOMOTIVES WITH PETROLEUM FUEL.

up the firing door both inside and outside, Fig. 34, thus adding 2½ square feet of very effective heating surface to the fire box, and obviating all possibility of leakage at the fire door ring, and making a neat job altogether. A sighthole is made through a hollow stay bolt, as shown in Fig. 34, and a manhole in the bottom of the asphan affords access to the interior of the fire box for repairs and inspection.

Verderber Boiler.—With regard to the further suggestion made by Mr. Tomlinson and Mr. Tomkins (Proceedings 1884, pages 299 and 314), that a more special construction of boiler should be employed for petroleum firing, the author is of opinion that it would be difficult to mature a better design than the present locomotive boiler for working at high pressures and giving great power in a comparatively small space. By way of experiment, however, without discarding the old locomotive boilers, the author has lately adopted a construction of boiler devoid of any internal fire box, which was first introduced by Mr. Stephan Ver-

* Paper read before the Inst. of Mechanical Engineers.—*Engineering.*

derber in 1879 on the Hungarian State Railways. A somewhat similar arrangement had been introduced in 1827 on the St. Etienne and Lyons Railway in France by Mr. Marc Seguin.

The Verderber boiler, as shown in Figs. 35 and 36, consists of a cylindrical shell, forming the boiler proper, and of an external fire box or furnace lined inside with fire brick. The fire box is completely separated from the boiler proper, and the only way in which it contributes directly to the evaporation of the water is by its radiation of heat to the tube plate. The fire brick lining causes the whole fire box surface to part as rapidly upon the back ends of the tubes for one third of their length. And to facilitate its removal some of the bottom tubes are omitted and a mudhole is provided in the boiler near the fire box. As the water space in the Verderber boiler is considerably diminished by the removal of the internal fire box, it is requisite, in order to maintain the same rate of evaporation, that the feed should be effected continuously by an injector adjusted for the mean rate of evaporation, so as to prevent too sudden fluctuations of water level.

A lagging of 2 in. thickness of slag wool outside the to maintain a regular temperature under irregularity of firing. The loss of heat by radiation from the furnace is decreased, in consequence of the fire brick lining, and of the fire door not having to be opened for firing. The increase in the number of tubes that can be got into the boiler, along with the extra heating surface due to the lengthening of the whole of the tubes by 2 ft. 1½ in. at the fire box end, more than compensates for the loss of fire box surface, although the latter surface is admittedly more profitable than that of the tubes for evaporation per square foot, as fully demonstrated by the experiments recorded by M.

MODIFIED VERDERBER FURNACE, GOODS ENGINES.

Fig. 38

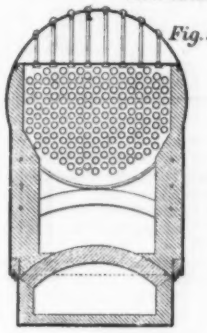
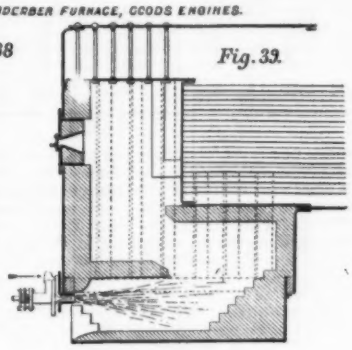


Fig. 39.



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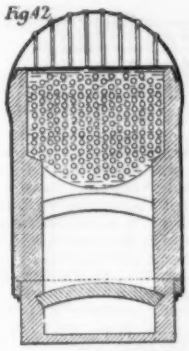

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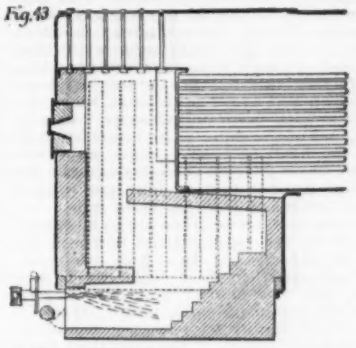


MODIFIED VERDERBER FURNACE, PASSNGER ENGINES

Fig. 40.

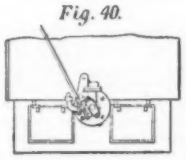


Fig. 41.

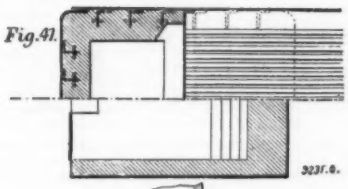


Fig. 44

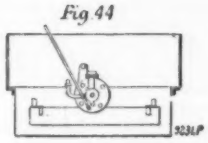
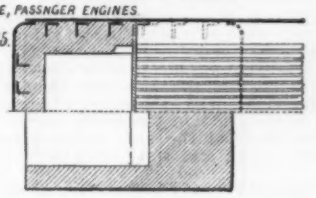


Fig. 45.



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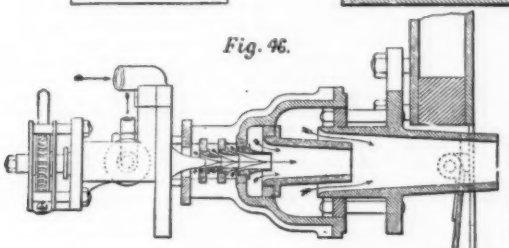


Spray injector, with Air blower.

Fig. 47. LUBRICATION.

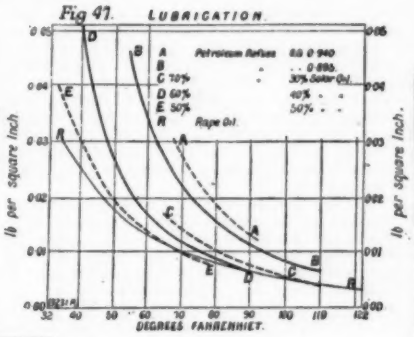


Fig 51

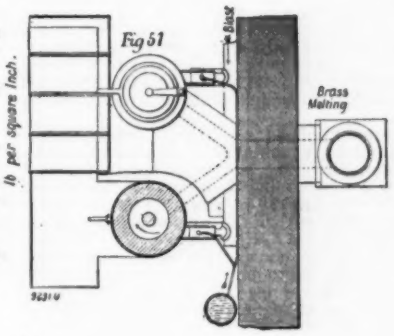
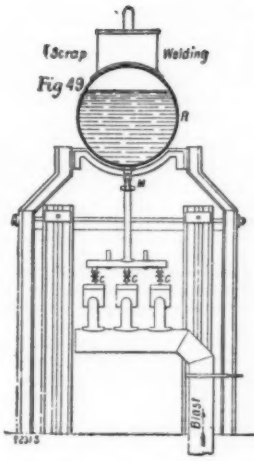


Fig 49



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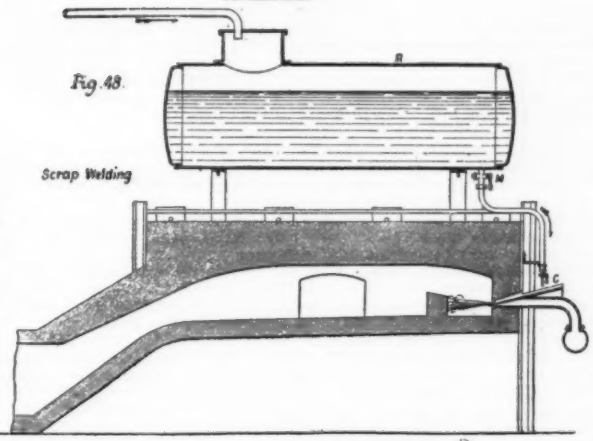


Fig 52

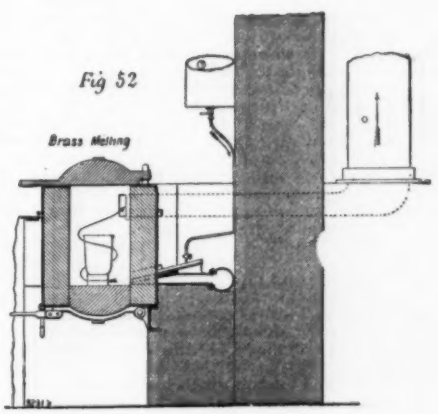
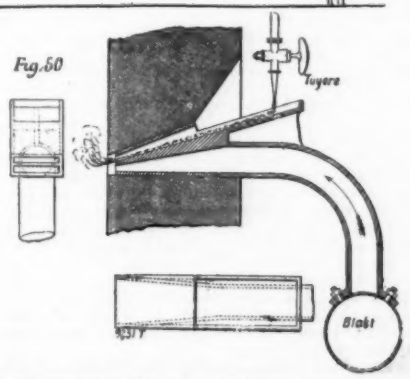


Fig. 50



WORKING LOCOMOTIVES WITH PETROLEUM FUEL.

take of the advantages of the fire brick arch already in general use in coal burning locomotives. The results of trials made with two locomotives, which differed only in one of them having the fire box thus modified, showed that there was an appreciable economy with the altered firebox, and that with the same combustion of coal the blast orifice must be closed more with the fire brick furnace, because the temperature in the furnace is some 630 deg. Fahr. higher, and consequently the volume of the gases passing through the tubes is increased nearly 35 per cent. The sediment ordinarily settling upon the fire box plates here settles fire box shell keeps the heat in sufficiently to allow of holding the hand upon it. The fire brick furnace has run five months without any shaking, the boiler making steam as usual. When in the shops for repairs, the cost of altering an engine to this plan would be not more than 50*l.*, whereas to renew a copper fire box in a large locomotive, with its multitude of stays and roof bolts and rivets, costs 250*l.*, or five times as much.

The large extent of the fire brick lining, while preventing damage to the boiler plates, tends also to insure the complete combustion of the liquid fuel, and Couche,* which are presented in a condensed form in Fig. 37.

Having occasion to renew some worn-out copper fire boxes, the author adopted a modification of the Verderber furnace for two locomotives, goods and passenger, fired with petroleum refuse, which have now been running over two years. From his own observations with these two locomotives he would have no hesitation in using the plan for all his boilers, as there is much about it which, in his opinion, recommends it for firing

* "Permanent Way, Rolling Stock, and Working of Railways," by Ch. Couche, vol. iii.

with liquid fuel. In Figs. 38 to 41 is shown the furnace of the goods engine, and in Figs. 42 to 45 that of the passenger engine. It will be seen that the brick arch forming the roof of the Verderber furnace is here replaced by a crown sheet which not only increases the water space of the boiler and adds some very useful heating surface, but also appears to the author to be indispensable, for the two following reasons: First, there could be no guarantee that the brick roof of the Verderber furnace would not come down some time while running, and so bring the train to a premature stop on the line. Secondly, the crown sheet having water on the top of it carries the water level back again to the original back plate of the fire box, where all the water gauge fittings are ordinarily mounted. The consumption of fuel per train mile with these fire brick furnaces is no more than with ordinary locomotive boilers having internal fire boxes. And the author is indeed disposed to conclude that there is a decided economy in their favor on this score. In comparison with engines of the same class but with ordinary fire boxes, the mean of several trials made with the Verderber fire boxes gave an economy of eight per cent. in passenger engines and of four per cent. in goods engines, in saving of fuel per train mile.

For greater satisfaction these trials are to be continued for one year in the regular train service. But the greatest advantages of the fire brick furnaces are the reduction in first cost and in cost of maintenance, and the shorter time the engines have to stand in the repairing shop, inasmuch as the boiler repairs amount simply to changing the tubes and renewing the brick lining of the furnace. Even with coal, with which Mr. Verderber's experiments were made, the evaporation attained per pound of fuel was equal to that with the ordinary firebox. The object of his plan, however, was not to effect economy in fuel, but rather to obviate the incessant damage to fireboxes and the consequent stoppages, which were caused by rapid incrustation in the water spaces surrounding the firebox, from the very bad feed water he had to contend with; and this object he fully attained.

The six-wheel coupled goods locomotive, of which the furnace is shown in Figs. 38 to 41, was altered in August, 1885, and has been running ever since; it had previously, when burning coal, 151 tubes 2¼ in. in diameter, and a total heating surface of 1,248 square feet, including 82 square feet in the firebox; it has now 157 tubes of the same diameter, and 2 ft. 1½ in. longer, which, with 13 square feet in the firebox roof, give a total heating surface of 1,410 square feet, or an increase of 162 square feet. As shown in Fig. 41, the firebrick lining is secured to the firebox shell by means of vertical angle irons riveted to the shell plates and embedded in the firebrick.

A special form of boiler for petroleum firing, designed by Mr. Paschinin, which may be described as something like a Cornish boiler having a larger internal firebox with a flue extending thence along the bottom of the barrel to the smokebox, and with tubes added above the flue, appeared to the author at the time of its suggestion to involve the serious structural defect that the expansion and contraction of the long flue, which would be exposed to much greater heat than any other part, must tend to tear its end connections to pieces in the absence of any arrangement for taking up the expansion. This proved to be the case with a boiler so constructed for the Transcaucasian Railway at the Kolomna Locomotive Works, near Moscow. Besides presenting so dangerous a defect, the few trials made with the engine showed that this boiler consumed more fuel than an ordinary boiler of the same class of engine; and it is therefore looked upon as a complete failure, at least for locomotive purposes.

Blower for Air Supply to Furnace.—The suggestion made by Mr. Crampton (Proceedings, 1884, page 307), that the air should be absolutely injected with the steam and oil, and mixed with them in the exact proportion required for perfect combustion, has been carried out by the author by combining the spray injector with an induction air blower, as shown in Fig. 46. The spray injector itself is the same as that ordinarily used, with simply the addition of three concentric nozzles, fixed one in front of another, so that the steam jet passing through them draws along with it a supply of air entering through the annular spaces between the cones. In a less developed form this idea had indeed already been adopted in his first and subsequent practice; but with the blower shown in Fig. 46 sufficient air is supplied for a full fire, even if the ashpan doors are closed altogether. This blower was fitted to a six-wheeled compound goods engine which had been altered from an ordinary locomotive during the summer of 1887.

It is more especially necessary in a compound locomotive, because the blast in that case is very soft and makes only two beats per revolution instead of four, whence some difficulty was encountered in getting the adequate supply of air into the fire box by means merely of the draught produced by the exhaust. The blower was, therefore, resorted to, whereby the difficulty was fully solved. As, however, no appreciable advantage in fuel economy was found to result from its use, while at the same time it was terribly noisy in working, it has now been discarded.

Compressed Air for Spray Injector.—Experiments were also made on the use of compressed air instead of steam for the spray injector. An air pump was fitted on the front cylinder cover on the right-hand side of a goods locomotive, so as to be under the driver's eyes; it was worked by the tail end of the piston rod, which passed through the cover and was fitted with a piston 6 in. in diameter, making, of course, the same stroke as the steam piston. The air pump was single acting, and compressed the air up to six atmospheres into a receiver provided with a spring safety valve. Thence the compressed air was conducted through a coil of 2 in. piping inside the smoke box, thus picking up a good deal of waste heat, which it then returned through the spray injector into the fire box. With this arrangement the engine ran two months, but no appreciable reduction in consumption of fuel was noticed, while a good deal of the engine power was exerted in compressing the air; and the air pump being only on one side, its working tended to give the engine a lurch sideways, which was noticed when running slow. A more serious fault, however, of the arrangement was that, when the engine was running up an incline, and the speed was consequently slow, as low, indeed, as eight miles per hour, too little air was then pumped into the receiver, although it was just at this time that a strong fire was required for supplying the extra quantity of steam needed on the incline; whereas in running down an incline the opposite was the case, too much air being compressed when none at all was required, as the fire was stopped altogether and the brakes were applied. Even if this twofold objection should be obviated, the author is of opinion, from what could be observed during the two months' trial, that the complication and cost of the extra gear would not be recouped by a sufficient economy in fuel consumption. The idea has, therefore, been completely abandoned, at least for locomotives, the boiler steam being found the most convenient agent for injecting the spray of petroleum refuse into the furnace.

TABLE VII.—THEORETICAL EVAPORATIVE VALUE OF PETROLEUM FUEL AND OF COAL.

Fuel.	Specific Gravity at 32 deg. Fahr. Water =1·000.	Chemical Composition.				Heating Power.	Theoretical Evaporation. Pounds of Water per Pound of Fuel.	
		Carbon.	Hydrogen.	Oxygen.	Sulphur.	British Thermal Units.	From and at 212 degrees Fahr.	At 8½ Atmo. Effective Pressure.
	S.G.	per cent.	per cent.	per cent.	per cent.	units.	lb.	lb.
Pennsylvania heavy crude oil	0·890	84·9	13·7	1·4	...	20,736	21·48	17·6
Caucasian light crude oil	0·884	86·3	13·6	0·1	....	22,027	22·79	18·9
Caucasian heavy crude oil	0·938	86·6	12·3	1·1	....	20,136	20·85	17·3
Petroleum refuse	0·928	87·1	11·7	1·2	....	19,832	20·53	17·1
Good English coal (mean of ninety-eight samples)	1·280	80·0	5·0	8·0	1·25	14,112	14·61	12·16

Evaporative Value of Petroleum Fuel.—In Table VII., which is a slightly modified reproduction of one given in the former paper (Proceedings, 1884, page 274), is shown the theoretical evaporative value of petroleum fuel in comparison with that of coal, as determined by Messrs. Favre and Silbermann. At an effective pressure of 8½ atmospheres or 125 lb. per square inch, the highest evaporative duty of the petroleum refuse used in the author's locomotives on the Grazi and Tsaritsin Railway has been 14 lb. of water per pound of fuel; in comparison with the theoretical evaporative value given in Table VII. of 17·1 lb., the actual efficiency of the fuel is, therefore, nearly 82 per cent. The only way of increasing the efficiency of liquid fuel appears to the author to be to make it into crude gas and work it on the regenerative principle; but such a plan, however successful it might be in metallurgical furnaces or indeed for stationary boilers, is quite inapplicable to locomotives.

Copper Tubes.—By way of experiment, with a view to raising the efficiency of petroleum fuel, the author fitted two locomotive boilers with solid drawn copper tubes of 3 mm. (0·079 in.) thickness and 2⅛ in. diameter, having thick copper ferrules brazed on the ends next the fire. With these tubes steam is made very readily, so much so that the blast pipe had to be increased in area. As these engines have only recently commenced running, the economy in fuel has not yet been ascertained; but the author has no doubt the copper tubes will produce an appreciable economy, and he will be happy to communicate the results as soon as they are fully known.

Lubrication.—The petroleum refuse burnt in the locomotives is also found to make an excellent lubricant, and for some years past nothing else has been used for the wagons and tenders, thus reducing expenditure considerably. The only thing necessary is to get it pure, without sand or grit; and, fortunately, this can readily be managed by skimming the cream off the top of the reservoirs in summer after they have stood some time for settling. In this way a very pure oil is obtained for lubrication, although black in color.

From laboratory experiments made at Borisoglebsk on the comparative qualities of petroleum refuse as a lubricant under varying conditions of temperature, it was found that in summer it can be used by itself as a lubricant for carriages, trucks, and tenders, and also for all pumping engines and other rough machinery. As cold sets in, it is indispensable to add to the petroleum refuse from 30 to 50 per cent. of solar oil, a mineral oil which is one of the products of distillation from crude petroleum, and has a specific gravity of 0·860 to 0·870 and a flashing point of 100° Cent. or 212° Fahr. As petroleum refuse by itself becomes in cold weather too thick to rise through a wick by capillary attraction, solar oil is added in proportion to the coldness of the atmosphere, so as to preserve the necessary fluidity.

In place of the usual plan of testing the value of a lubricating oil by measuring the external friction of rubbing surfaces lubricated therewith, the novel idea occurred to Prof. N. P. Peteroff, professor of mechanics in the Technological Institute, St. Petersburg, of measuring the internal friction among the molecules of the oil itself. For this purpose a sample of the oil to be measured is passed with a definite pressure through a glass tube of 1½ mm.=0·06 in. bore and 505 mm.=20 in. length, which is immersed in a water bath kept at various temperatures; and the friction is determined by the time required for passing a measured quantity of oil through the tube. The results, expressed originally in milligrammes of pressure per square millimeter of bore of the glass tube, are represented by the curves plotted in the diagram, Fig. 47, in which the scale of pressure has been converted to hundredths of a pound per square inch of bore.

As a standard for comparison the friction of rape oil is taken, which is represented by the curve R R. Petroleum refuse used by itself, without admixture, gives the two curves, A and B, of which A represents the petroleum refuse used by the author in February, 1886, having a specific gravity of 0·904 at 20° C. or 68° F.; and B represents that used in July, 1885, having a specific gravity of 0·895 at the same temperature. The three curves, C, D, E, correspond respectively with admixtures of 30, 40, and 50 per cent. of solar oil; the two higher percentages are employed in very cold weather, while 30 per cent. is the admixture used in spring and autumn.

At temperatures of from 40° to 45° C., or 104° to 113° F., it will be noticed that the friction of petroleum refuse by itself in the line, B B, approaches pretty near that of rape oil in the line, R R; while the addition of 30 per cent. of solar oil, as shown by the line, C C, reduces the friction to the same as with rape oil at the above temperature, thus rendering the train resistance consequently the same. Similarly, the lines, D D and E E, show respectively the same friction as rape oil at the lower temperatures of about 32° and 18° C., or 90° and 64° F.

Now that petroleum seems destined to occupy a prominent place in India as well as in many other parts of the world, these results in regard to its value as a lubricant can hardly fail to be of interest to engineers, irrespective of its use as a fuel.

ADDENDUM TO SUPPLEMENTARY PAPER ON THE USE OF PETROLEUM REFUSE AS FUEL IN LOCOMOTIVE ENGINES.

Scrap-welding Furnaces.—In Figs. 48 and 49 are shown a longitudinal section and end elevation of the larger of two scrap-welding furnaces, fired with petroleum refuse, which have been in daily use for about three years at the Borisoglebsk works, and are giving perfect satisfaction. The body of the furnace is of the usual reverberatory form, and in place of a fire grate it has three air spray injectors at the firing end, which are placed almost on a level with the bridge. Through these three blast injectors the whole of the air required for combustion is supplied. As no unconsumable particles exist in the fuel, no ash pit is required, and no cleaning is necessary during the working; hence the furnace can work continuously so long as the roof does not get burned out.

It also slags very freely, thus proving that quite sufficient heat is available for all practical purposes. The blast used is cold and from the ordinary smithy main. It was at one time contemplated to heat the air by the waste heat from the furnace itself; but being short of boiler power, the author had to utilize the waste heat from both these welding furnaces for heating a large elephant boiler erected close by, which now supplies almost sufficient steam for the steam hammers and rolling mill. The petroleum reservoir, R, is placed right above the larger furnace, in order that during winter the refuse may be kept in a liquid state by the heat radiating from the furnace; it supplies both furnaces through a separate pipe to each. Besides a main cock, M, on the pipe to each furnace, there are also three half-inch cocks, C C C, for regulating minutely the supply of fuel to the three spray injectors of the larger furnace.

The liquid trickling from these cocks spreads into a thin film upon an inclined shoot cast in one piece with the blast pipe, which terminates at the furnace end in a wide, flat tuyere, as shown full size in Fig. 50. The blast issuing from this broad rectangular orifice carries with it in the form of spray the thin flat film of petroleum dropping from the orifice above; and the jet striking against the low bridge, half a brick high, produces a thorough mixture of air and gas, the proportions of which are so accurately regulated that a perfect white welding heat is maintained in the furnace without any smoke being emitted. The larger furnace has three blast injectors, while the smaller requires only two. The same construction of blast injector is now used also in the tire fires, in place of the circular tuyere nozzles previously employed (Proceedings, 1884, Plate 59).

The great simplicity of the appliances for thoroughly utilizing liquid fuel for metallurgical purposes, even for forgings of the largest size, commends itself in any country where this fuel can be had at a cheap rate.

As no trace of sulphur exists in petroleum refuse, no deteriorating effect can take place upon the iron. With coal, especially Russian bituminous from the Donetz coal basin in South Russia, which is rich in sulphur, it is impossible to get iron of first-rate quality. In tests made on iron rolled from poor unwashed scrap welded with liquid fuel it was invariably found that a very homogeneous ductile metal of high quality was produced. As compared with coal, a saving is effected of 40 per cent. in weight of fuel, besides the output being considerably increased.

On Monday mornings three and a half hours are required for heating the larger furnace up to a white heat, with a total consumption of 540 lb. of petroleum refuse. On all other days in the week one and three hours are required, with a consumption of 125 lb. To make one ton of blooms in the larger furnace alone, from small unwashed scrap three times welded, requires a consumption of 17 cwt. of petroleum, with a loss of iron of from 18 to 20 per cent. In practice, however, both furnaces are at work at the same time, and the blooms are passed from one to the other when being hammered, thus keeping the heat up in blooms and furnaces and reducing the consumption of petroleum to 13 cwt. per ton of rolled bars of light sections.

Brass-melting Fires.—In Figs. 51 and 52 are shown a plan and vertical section of the two brass-melting furnaces using liquid fuel, which the author has also had in daily work now about three years with entire satisfaction. The same fires were formerly used with coke as fuel. They are of the well known make having drop bottoms, which, however, are not now used, as no unconsumed residue remains in the furnace. The same blast tuyere is used here as in the welding furnaces and tire fires. One is quite sufficient for each brass fire, and is set tangentially to it, as shown in the plan, thereby giving a whirling motion to the flame,

which, coming in contact with the white-hot fire brick lining, insures complete combustion of all the particles it contains. The blast used is cold, and supplied with an ordinary fan. Besides occasioning a much cleaner foundry, free from sulphurous fumes, the adoption of petroleum in place of coke has resulted in a sensible economy in fuel, as well as a saving of time in melting.

The results are as follows :

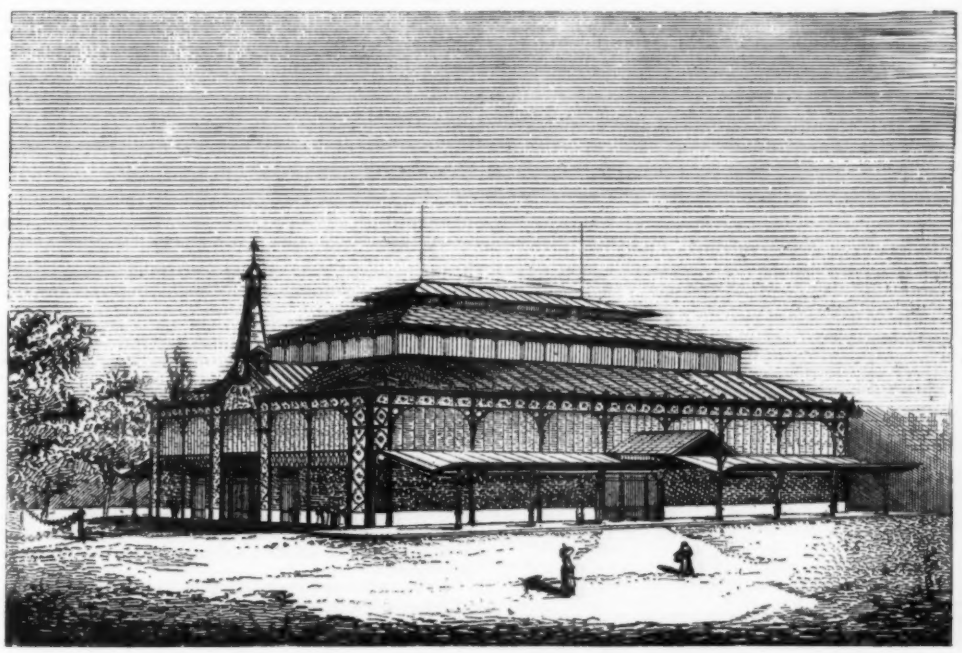
With coke, 40 lb. of brass castings were made with 35 lb. of fuel and 10 per cent. loss of metal, while with petroleum refuse 40 lb. of brass castings are made with 18 lb. of fuel, and only 6 to 7 per cent. loss of metal, and with 25 per cent. saving in time.

It is, of course, quite possible that a better arrangement could be made for this purpose. But, as in the case of locomotives, the plan here shown is the simplest and most direct way of applying the liquid fuel under existing circumstances, and the author has been so satisfied with the results that he has not seen any necessity for further experimenting.

THE ROCHE-SUR-YON COVERED MARKET.

IN the spring of 1886 the city of Roche-sur-Yon put up for competition a project for a covered market. It addressed the principal builders who were specialists in the matter, asking them to present both a project and a specification. As a result of this competition, and upon the report of the committee appointed by the municipal council to examine the work of the competitors, the project presented by Mr. Michelin, of Paris, obtained the majority of votes, and its author was charged with the carrying of it out. The work was pushed forward rapidly, and the market was recently inaugurated.

This market consists of a rectangular hall with a frontage of 98 and a depth of 130 feet. It is flanked by two lateral awnings 16 feet in width, giving a total superficies of 17,200 square feet of earth covered.



THE ROCHE-SUR-YON COVERED MARKET.

The interior arrangement is such as to meet the requirements and usages of the locality. There are 99 stalls, distributed as follows :

19 for butchers,
10 for fish dealers,
30 for fruit dealers,
40 for dealers in various provisions.

The awnings are designed especially for sheltering small country dealers—peasants who come quite irregularly. These arrive in crowds on market days in order to sell their commodities, fowl, butter, eggs, etc., and find a shelter under these awnings, which, on ordinary days, are used by the peddlers and itinerant merchants who travel about the city.

Spacious cellars situated under the extreme bays are used by the merchants as store rooms. These cellars are provided with compartments formed of iron lattice work. The floor is covered with Portland cement in order to facilitate washing.

The establishment of this market cost $40,328.—*Le Genie Civil.*

[Continued from SUPPLEMENT, No. 769, page 12287.]

REFRACTORY MATERIALS.*

By T. EGLESTON, Ph.D.

MIXTURES AND TREATMENT.

THE clay, when mined, is left exposed to the air under sheds, and is cleaned and carefully dried, and is afterward mixed with the substances with which it is to be incorporated, which are classified by numbers, varying according to the size of the sieve holes through which they will pass. The quantity and quality of the mixture will determine the refractory nature of the material to be produced. A friable paste with large grains, and quite porous, resists a great heat. One with fine grains, close and compact, splits at a high heat, especially if it is not homogeneous. The manner in which the mixture is made also influences the quality of the brick quite as much as the material. In some works in Belgium, after taking all the ordinary precautions to make the mixture perfect, it is submitted to a succession of shocks continued for some time, until it is found by experiment that the materials are perfectly mixed. It has been found by long experience that the bricks so made keep their form perfectly, while others made of exactly the same mixture in the ordinary way contract. The quantity and size of the mixture depend upon the size of the article to be manufactured. When coarse grains are used, greater thickness must be given to the sides of the articles if they are hollow, and they must be made larger if they are solid, thus giving a mechanical cohesion where a chemical one is wanting. The usual quantities of the mixture for bricks are three-fifths to two-thirds of the substances added to two-fifths to one-third of the clay, these quantities being determined by volume and not by weight. When coke dust is used, it does not seem to have any decided effect beyond one-tenth. The action of coke or graphite is to decompose the metallic oxides as they form, and thus prevent their union with the material of the crucible. Coke may be profitably used in the place of graphite when the ash is in small quantity, free from iron and highly aluminous. Beyond two to three per cent. of graphite cannot be profitably used, as it weakens the article and renders it liable to break. The mixture which gives the very best results for small articles is, however, worthless for large. It will generally be found that the pieces which crack up and down in drying have had too much material mixed with the clay, and those which crack laterally have had too much clay.

The very greatest importance is attached in some industries to not having a mixture made by a machine. In most places even to this day the inhuman method of heel treading is used, because more care is then exercised, or because, smaller quantities being mixed at once, better results are obtained. The more the operations of mixing are repeated, the better the material, and it is undoubtedly true that with mechanical means such a homogeneous paste is not produced as can be made by human labor, because the whole object of the machine is to operate on large quantities at a time.

TEMPERING.

The paste made, and the article completed, it must be dried or "tempered." This is commenced in the open air, and, if possible, out of the draught. If the draught cannot be excluded, the place where the drying takes place is slightly heated, commencing at a temperature from 60 deg. to 70 deg. F., and keeping it up from twenty-five to thirty days, then increasing it from 80 deg. to 100 deg., leaving the article as long as possible, with an active ventilation, but the same temperature being kept up. The article should remain in a temperature of from 150 deg. to 180 deg. for at least six weeks. Bricks do not generally require so much care, but crucibles and retorts do. Long experience has proved that there is a great economy in conducting this process of tempering as slowly as possible, and that it influences materially the refractory nature of the article. It is found by actual experiment in crucible works that those crucibles made from the same mixture, tempered during six to eight months, last more than three times as long as those which had been tempered only two; so that in general, the older the article before being burned, the better. This desiccation, while, perhaps, it is the most important part of this manufacture, is undoubtedly the one most neglected. A poor article well tempered is often better than the best which has been hastily dried. By working rapidly, and filling up cracks as they form in a too rapidly heated drying house, with a very liquid material, in order to secure complete penetration, both time and money are lost. The material never lasts nearly so long as when slowly dried.

In the works at Andenne, in Belgium, large pieces, like glass house pots, are kept six months in the drying house before they are burned, and during this time the greatest care is taken to prevent draughts, so that no air colder than the drying room shall strike them. Leaving the door of the drying furnace open has been known to crack the pieces, which had been up to this point most carefully prepared and tempered.

EXPANSION AND CONTRACTION.

In reviewing the effects which the different elements which constitute refractory materials have, we find that the same element often produces exactly contrary effects, according to the proportion in which it is present, and that there is nothing anomalous in effects being so produced. Silica causes expansion when highly heated, so that the moulds in which the bricks are made must be smaller than the brick is to be. Every mixture has its own peculiar rate of expansion and contraction. This expansion not only takes place when the bricks are made, but if when used they are submitted to a higher degree of heat, they expand still further, and contract again on cooling to such an extent that at Dowlais the tie rods of the steel furnace are slackened when the furnace is getting into heat, and are tightened again as it cools. At Crewe this is made self-acting by means of springs. At Creusot the furnace casing is made so strong as to resist the pressure, so that the roof arch must rise and fall to allow for the expansion and contraction. When neutral brick must be had for any reason, it is mixed with just enough clay and burned brick to make it keep its form, and such a brick is generally less fusible, the less silica it contains.

FLUXES.

Alumina alone, or with silica in the proportion of thirty to thirty-eight per cent., is very refractory; but three per cent. of it in a silica brick makes it fusible. In clay, or pure, it tends to contract, and this tendency is greater as the alumina is in greater quantity, and the heat of manufacture has been low, but when it has been very highly heated at first, it afterward undergoes but little change. Though both silica and alumina affect each other so unfavorably, Bischoff found that four of alumina to one of silica, or two to one, or one to one, only sintered before the oxyhydrogen blowpipe, making masses with a granular fracture. One of alumina to two of silica was fusible like porcelain, but still somewhat granular. One of alumina to four of silica and one of alumina to six of silica melted like a thick enamel, which shows that the acid silicates of alumina are much more fusible than the basic. He also found that a mechanical admixture of alumina and silica was less fusible than the same amount in a natural combination, and that, in general, silicates already formed are more fusible than a mixture of their constituents. The general property of alumina, when mixed with other substances, is to bind them together. When combined with iron or other bases alone, it makes infusible aluminates; but if silica is present, it fuses more or less easily. It is generally conceded that the proportion of alumina in a brick should be between 10·20 and 25 per cent.

The alkalies in small quantity make a brick fusible. There is a great difference of opinion among those who have studied this subject with regard to the quantity. Mr. Snelus states positively that one per cent. of alkalies in an otherwise good material makes it too fusible to withstand high temperatures. Mr. Riley states, with equal positiveness, that he has found brick containing 2·73 per cent. of potash to resist the greatest heat of a Siemens-Martin furnace. It is probable that both are right, and that in the special cases alluded to the peculiarities were owing to the association of elements. In any case, a material with a very small percentage of alkalies cannot be used.

Lime alone is completely infusible; but in very small quantities in a clay it makes a brick fusible at high temperatures. Two per cent. of it with silica makes the most infusible brick known.

Magnesia in small quantities makes the clay fusible. In very large quantities it is very refractory. Alone, it is entirely infusible.

Oxide of iron, in the absence of alkalies, may be present in small quantities without seriously affecting a clay, unless it is to be used for melting steel. If alkalies are present, any proportion of iron would make such a clay worthless. If no silica at all is present, 5 or 6 per cent. may not damage it. In a silica brick 2 to 3 per cent. of iron makes the brick worthless. If the iron was always certain to remain in the state of a sesquioxide, its compounds would be much more infusible, and a large percentage would do no injury; but some of the sesquioxide is certain to become reduced to protoxide in the presence of reducing gases, and the result is a very fusible compound in the presence of silica. There is a still more deleterious and dangerous effect of iron in firebrick, because its effects are produced, not at a high heat, but at a comparatively low temperature. It is well known, from the researches of Bell and others, that when a brick containing iron is exposed, even at a low temperature, to gases containing carbon, part of this carbon is deposited near the iron; this has often not only caused the brick to lose its cohesion, but has even burst it, so as to throw down the in-walls of furnaces and the linings of flues. The presence of iron is, therefore, doubly to be dreaded, as in the presence of reducing gases it is quite as deleterious at low temperatures as at high.

As much as 1 per cent. of titanium has been found in some clays. Little is known about it, but it appears to act like silica.

Bischoff found that 20 per cent. of magnesia, 28 of lime, 47·1 of potash, or 40 of iron had exactly the same effect in making the clays fusible, and that when 4 and 2 of the different bases were used, the relation was striking, and in about the same order. The quantity of other substances necessary to make a compound fusible depends upon the quantity of silica present—the more silica, the less of the other substances. It will thus be seen that while the predominance of any one element will materially affect the nature of the materials, it is more the way in which the different ingredients are grouped together than their individual percentages which affects the nature of the brick, and frequently, above all these, the mechanical and molecular arrangement of the particles which determines its commercial value.

ESSENTIAL QUALITIES OF GOOD FIRE BRICKS, ETC.

The essential qualities of a good brick may be stated as follows: First, infusibility; second, regularity of shape and the power to retain it under all circumstances, which involves perfect uniformity of composition; third, strength to resist the different pressures required under different circumstances; and fourth, its cheap price.

* This article was written at the suggestion of the Committee on Refractory Materials of the American Institute of Mining Engineers, with a view of calling attention to the anomalies and difficulties of the subject. It was hoped that its discussion would eventually lead to the appointment of a commission, by the great metallurgical interests of the United States, to investigate the whole subject, since it is believed that a better and cheaper artificial product can be made than any now in use, and that many other important incidental results would be accomplished by such an investigation.—*Brickmaker.*

No material yet manufactured fulfills all these conditions; but there seems to be no reason why, with the proper investigation, a material should not be made which will fulfill most of them. The metallurgical world is nearly agreed that the refractory material of the future must be made artificially, and that it is hopeless to look for it among natural products. No brick can come up to the modern standard of infusibility which contains 5 per cent. of iron, or 3 per cent. of combined alkalies or alkaline earths, yet the most infusible brick that is known, which in the roof of a Siemens-Martin furnace will resist 350 charges, and then wear out by abrasion, when required to come in contact with metals, oxides, and alkalies in a spiegel cupola, will hardly stand twenty-five heats, while an iron pipe coil, which is easily destroyed by heat, will last almost indefinitely in the same cupola, provided only a sufficient stream of water is run through it. Different furnaces, and different parts of the same furnace, should, therefore, be treated differently, instead of being treated by the same procrustean methods, as is frequently the case. If silica makes the best roof, it makes the worst hearth. Alumina, when present in very large quantities, even in the presence of a small amount of silica, makes compounds which are almost infusible, so that it should be used for the fire bridges and hearths, and not be put into the roof, where its tendency to contract would endanger the structure of the furnace.

Far too little attention has been given to the abrasive and corrosive power of coal dust and ashes carried by the draught in gradually cutting and fluxing away the parts of the furnace exposed to its action, and many qualities of brick which are infusible in the assay owe their small power of resistance to its effect. A brick to be used where it is to be exposed to such action should always be tested by placing it for a considerable time on the bridge of the furnace where it is to be used, for the destructive effects of this almost unobserved agency seem to be greater than those of long-continued heat.

A good brick should not only resist high temperatures, but sudden changes of temperature, without alteration of any kind, such as crushing, splitting, etc., and at a high temperature should undergo the least possible change of form. In general, it may be said that bricks which have undergone a very high temperature in the manufacture are less liable to contract afterward. Shrinkage is generally due to insufficient burning, or to a too small proportion of old material in the mixture, and generally occurs in aluminous bricks. Its chief evil is in allowing the flame to penetrate the open joints and give the dust an opportunity to cut between the bricks, for any cause which produces eddies in the flames, such as hollows or projecting surfaces, is certain to effect the destruction of that part of the furnace. Siliceous bricks have, on the contrary, a tendency to expand under the influence of intense heat. This is true to such an extent that in the steel furnace where they are used, provision must be made for slackening the tie rods when the fire is being raised and tightening them when it is being cooled.

The crushing weight of an ordinary fire brick, cold, is from 600 to 1,000 pounds, but some of the best have been known to resist as high as 3,000 pounds to the square inch. To insure the safety of the structure, and the success of the process, it should not only retain its power of resistance, but should not undergo any change of form nor soften materially under long-continued heat, and at the highest possible temperature should support more than double the strain required without alteration. In the walls of the fireplace those bricks will be best which are dense, and contain an excess of silica. In the hearth they should contain an excess of alumina. In the arch they should be nearly pure silica, alumina, or magnesia. Bricks in a roof give out from shrinkage, cracking, or splintering. Splintering may take place when silicate bricks are made of impure mixtures, but it is usually caused from too much fine material and from imperfect burning. Brick which are liable to splinter are generally cross-grained and dense, with a smooth conchoidal fracture, when made from improper mixtures, and when from bad burning they generally ring like a cracked vessel. All good bricks wear off evenly.

No matter how good a material may be, if its price is so high as to prevent healthful competition, it might as well not exist. Hence any effort to furnish a good material should have for its aim to produce it at the least possible cost.

In discussing the manufacture of a refractory material which is to be used in a given locality there is to be taken into account, first, the clay and other materials to be had; second, the ore or metal to be treated; third, the fuel to be used; and fourth, the foreign substances in the gangue of the ore or metal. Whether to use a given clay, or a mixture of calcined or raw clay, must be determined by direct experiment, and then the size of the grains of the mixture for the special use must be determined, for each substance is more or less refractory according as it is coarse or fine. Thus, in Belgium a porous material with a large grain is used for blast furnace brick, but a fine material with a close grain for coke furnaces, the chemical composition being the same in both cases. It must then be ascertained whether the mixture contracts or expands, for there are clays that contract and expand between one-thirty second and one-eighth. The way in which material tempers must then be carefully studied. It is not sufficient to have a good material, for almost as much depends on its manipulation as on the material itself. To temper properly, the clay and the manufactured article should both be dried gradually and uniformly. It must be fired evenly, and the temperature slowly raised to the proper point. If it is to be used in the raw state as ganister, it must be equally moist throughout, so as to dry uniformly, and not so wet as to cause it to crack in drying or so dry as to prevent its binding. The brick, or other materials, once made, should be kept from dampness. As they are porous, and likely to absorb moisture, they should be heated before being used in the furnace, and put in as hot as it is possible to handle them. If the furnace is in blast, this requires a special furnace and a high heat. If it is to be put in blast at once, especially with silica bricks, the temperature should be as high as the hand can bear. If the furnace is to be a long time standing, this precaution is not necessary, but in the two last cases the furnace must be dried very carefully and slowly. No brick which has been dressed should ever have the dressed face exposed to the flame. Without the observation of these precautions a really good brick may give a very bad result. It is too much the habit of this age to be in a hurry to get results, and this has led some blast furnace managers to boast that steam was issuing from the top of their furnace while cast iron was being tapped from the bottom; but under such management we never hear of long campaigns, but very frequently hear of disasters.

It is thus seen that a brick which is good for the cupola would be worthless for the reverberatory furnace, that which answers well for iron would generally be worthless for zinc, and a crucible which is excellent for steel cannot be used for brass. It is not the way to realize progress to keep analyzing natural substances until we find the right one, or make repeated trials and depend upon them alone. All investigations go to show that we should look for artificial, and not for natural compounds; and that when we have made a mixture which has stood well, we are then to analyze and examine it in order to reproduce it. Failure in this, as in many other cases, is very often owing to wrong application of good materials, rather than fault in the materials themselves.

It seems probable that the use of water for cooling the refractory substances, and thus preventing them from attaining the heat necessary to destroy them, will in the future be used to a very large extent. Its application deserves the most serious attention.

INVESTIGATIONS ON REFRACTORY MATERIALS.

It is evident that no real progress can ever be made by any haphazard investigation. Chemical examination is, to a certain extent, a guide; but taken alone, it does not lead to any certain conclusion, for materials which on mere chemical analysis have been theoretically declared worthless have, in actual practice, on account of some physical peculiarity which escaped observation, been shown to be of great value. Besides, a substance of no value alone may, in a mixture, be an almost indispensable article. To the analysis must be added the assay, and when these have both been carefully made, the commercial trial. After this has been done, there should be a complete chemical, microscopical and physical examination of the substance to determine what physical or mechanical changes have taken place, or whether it has or has not undergone deterioration. Only the general outline of such an investigation could be traced beforehand. Almost all of the investigations on refractory materials which have up to this time been made have been undertaken by private parties in their own interests, and the results, either good or bad, have generally been carefully kept secret, so that when the same information is required it must be repeated, and the expense incurred over and over again. A thorough investigation would take a long time; probably no one company would be justified in bearing the whole expense of it, since to be really useful the results, as they are ascertained, should be published; but there is no doubt that if wisely planned and carried out it would save millions of dollars every year to the iron and steel industries alone.

PHOTO-MICROGRAPHY.*

By Andrew Pringle.

It may perchance be matter of wonder as well as of interest to some of you that the history of general photography has been to a great extent bound up with the history and record of photo-micrography; not that the special application of photography to microscopy has in any direct way influenced general photography, but rather because the men trained by education, and perhaps fitted by nature, for microscopic study, which is equivalent to saying minute and accurate observation, have found photographic *technique* useful, and have turned their observant minds to photographic wants.

And, moreover, images projected by a microscope are so evidently convenient for the study of any method of graphic representation—the enlarged image can so readily be kept steadily fixed on one plane, the optical qualities of the protected image can be so readily examined, the worker is so wholly independent of weather—that there is not much cause for wonder in our finding some of the earliest experimentalists in photography using the projected microscopic image as the subject for their photographic researches. Last year I had the honor to review before you the progress of photography during fifty years, but this year I take you back, if you will be pleased to accompany me, to a period more remote than fifty years ago. Let us turn to the year 1802, and we shall find—probably in the *Journal* of the Royal Institution—records of the experiments of Wedgwood and the observations of Humphry Davy on "leaves and wings of insects taken by solar light on prepared leather." This surely is early enough in the history of photography. It is well known that both Fox Talbot and the Rev. J. B. Reade used the solar microscope, and many other names famous in the records of photography are also found in the early annals of photo-micrography. Mr. Reade is known to have produced photo-micrographs in 1837, insects being his chief subjects, but in 1839 he produced results greatly superior to his efforts of 1837. About 1838 the prototype of our triple achromatic condenser was brought forward by Dujardin, and in 1839 or 1840 Daucer used the gas microscope and photographed therewith on silvered plates. Donne and Foucault, in Paris, presented engravings from photo-micrographic daguerreotype plates in what Moitessier called a "magnificent atlas."

The first instance known to me of the use of polarized light for photography was in 1857, when M. Bertsch exhibited in Paris crystals of salicine photographed by polarized light. About the "fifties" a great many names are found, many of them well known to us, as Shewbolt, Diamond, Maddox, Wenham, Viles, besides many *savants* of other countries. Dr. Maddox showed at the Royal Society, in 1867, photo-micrographs illustrating a paper he then read.

Enormous strides were made in our science by Dr. Woodward, an army surgeon of the United States. In fact, his work may be said not only to mark, but to constitute, an era in photo-micrography. His work first claimed notice about 1864, and consisted not only of medical subjects, but of diatoms taken at very high magnifications.

I am not aware of the exact date when Dr. R. L. Maddox first produced a photo-micrograph, nor can he fix the date himself, but I have here a photograph of P. Angulatum × 3000 diameters of superlative excellence produced by my friend in 1838 or 1839. This was by no means his first attempt, as is easily seen from the high quality of the negative now in my possession.

It is not within my subject to describe even briefly the apparatus used by these early workers, but I may say that the illumination used by them was either the gas microscope or sunlight, and many ingenious forms of heliostat were used. Dr. Woodward's heliostat was specially admirable, and Dr. Maddox designed one of high quality and moderate price. Still, in this country at least, direct sunlight can never be depended upon, and in the days of wet collodion the photo-micrographer must have had frequently to lie idle. In the present day, with the much more sensitive plates at our command, we can utilize as radiants not only the electric arc, but electric incandescent lamps, such, for example, as Dr. Van Heurck uses with such success, lime light, such as I use myself, and even the light of ordinary paraffin lamps.

Perhaps I may be excused if I dwell with a certain fondness on the photography of bacteria. I believe that Dr. Robert Koch, the eminent bacteriologist of Berlin, was the first to publish photographs of bacteria.

This was in 1877. In his paper *On the Investigation of Pathogenic Organisms*, translated by Mr. Victor Horsley for the New Sydenham Society, Koch speaks very strongly in favor of photo-micrography, and even says he would prefer a bad photograph to a drawing, however good, but it seems that at a later period he found certain difficulties of color to be almost or quite insuperable, and he was then inclined to make less of photo-micrography than he had previously done. Dr. E. Klein, F.R.S., was also inclined to condemn our science for his purpose, for in *Micro-Organisms and Disease*, third edition, 1886, I find these words: "Micro-photography, by which microscopic specimens of bacteria are photographed, has hitherto yielded results so unsatisfactory that even Koch, who first introduced it, has abandoned it in lieu of accurate drawings made in the usual manner."

Possibly, when Dr. Klein wrote this, his words were true, but certainly he has changed his opinion now, as I have very good reason to know.

I could name a considerable number of books and a very great number of papers which are illustrated by photography. George M. Sternberg not only illustrated a book of his own on bacteria by photo-micrographic prints (second edition, 1883), but has written a book of careful and detailed instructions for the practice of the science. Dr. E. M. Crookshank is in the same position. He has published a book largely illustrated by photographs of bacteria, and he is also the author of *Photography of Bacteria*. A paper read by Dr. Crookshank to the Photographic Society of Great Britain, and illustrated by his negatives, first directed my attention to bacteriological photography. In 1885 both Hauser and Van Ermengen published photographs of bacteria, and after the works of these men the science may be said to have gained a sure footing. The chief obstacle to success, the stumbling block of all these earlier workers, was the difficulty of *color* rendering, unless the preparations were suitably or deliberately stained for photography. Color-correct photography, then, forms one of the foundation stones of the edifice of photo-micrography so rapidly rising among us.

My remarks up this point have been purposely made to lead up to certain stages in the records of photo-micrography, and we have reached the stage of color-correct rendering of stained objects. There is another photographic matter which has been alluded to in passing, but must now be more particularly treated. I have referred to increased sensitiveness of our plates. Just as Wedgwood, Davy, Reade, and Talbot used photography for microscopic work, and in practicing the one elaborated the other, so Dr. Maddox in the search after certain photo-micrographic effects fell upon gelatine emulsion photography. I need not tell you how Bennett revolutionized photography, but I must point out the effect his discovery had on photo-micrography.

We are no longer dependent on sunlight, we can work with the very highest powers without undue length of exposure, the developed image is quite fine enough for any purpose, and nearly all the difficulties and inconveniences of wet collodion and silver bath are removed from our path. The advantage in reduced exposure is not by any means a matter of time only, for during prolonged exposure there is imminent danger of movement either from tremor or from alterations of temperature, both of which are fatal to success, but most difficult to avoid. We have, then, at the present day advantages purely photographic which were not within reach of the masters of photo-micrography of past years; we have plates much more sensitive, and so we get results much more rapidly, much more certainly, and with much less expense. But in a large class of cases we get results much better—sometimes, in fact, we get results which without orthochromatic photography we could not obtain at all.

The indefatigable Koch was stopped by color difficulties, as already stated. But it is interesting to know that, so far as I have seen, the very best photographs of bacteria published up to the present time are by Drs. Fraenckel and Pfeiffer, colleagues or assistants of Koch. These bacteriological photographs are so fine that I have brought a few of them for your inspection.

They are all, or nearly all, produced by orthochromatic methods, and while I cannot quite agree with all the directions given in the text of No. 1, still there can be but one opinion as to the results these gentlemen have achieved.

I would point out that some of the methods of staining most followed by bacteriologists and microscopic technologists in general would afford excellent examples of subjects difficult to photograph on ordinary plates.

Tubercle bacilli are usually stained either red on a blue ground or blue on a yellow brown ground. Violet colored *bacilli anthracis* are very frequently

* Recently read before the Photographic Convention of the United Kingdom.

found in preparations counterstained with Bismarck brown or vesuvin. The fungus of *actinomycosis* shows best stained blue, red, and yellow, and I shall presently show you the orthochromatic results from such a staining. A much valued multiple stain, my own favorite stain for ordinary pathological and physiological tissues, consists of bright blue for nuclear, bright red for connective, and orange more or less bright for protoplasmic tissues. I venture to assert that no ordinary plate will properly render a section well stained by this method, yet with yellow sensitive plates and the use of screens chosen for each occasion I am in the frequent habit of photographing such subjects, and I usually end by getting good results. I could show you bacteria sections photographed repeatedly on ordinary plates, and with the greatest skill and care I could bring to bear, where there is not a trace of a microbe, whereas with a color-corrected plate the organisms stand out clear and unmistakable. My paper is not intended to be a course of instruction in photo-micrography, but is rather an attempt to point out by how much and by what means our science has advanced, is advancing and will doubtless continue to advance.

The advances made since the infancy of our science have been simply astounding. Conceive the time and conceive the labor when the principle of "correcting lenses for photography" was undiscovered. Petzval, about fifty years ago, showed the way to this correction in photographic lenses, but not till long after that did photo micrography become so important in public estimation that opticians were forced to consider the correction for microscopic objectives. Some opticians do not seem to have grasped the subject even yet, but there are others who have done so most successfully.

And again, resolution and definition, which, though perhaps technically distinct, are nevertheless bound together, depend on angular, or rather numerical aperture.

The earlier opticians might get their objectives with visual and chemical foci coincident. They certainly did attain to very flat field images. But they were incompetent, and, indeed, do not seem to have been desirous to get large aperture with other qualities good. Resolution, or separation line from line, depends on fixed laws relating to numerical aperture. A lens having a numerical aperture of 0·30 will in the most actinic part of the spectrum resolve 38,000 lines to an inch. N.A. 1·00 (the highest air angle) gives the power of resolving 127,000 to the inch, while N.A. 1·4 is capable of resolving nearly 180,000 per inch. Now many of us possess objectives having apertures nearly approaching to N. A. 1·4, while lately Zeiss produced a glass having a numerical aperture of 1·63. I shall show you some work done with this glass by Dr. Van Heurck, of Antwerp.

When the system of immersion was introduced an enormous stride was made, and an enormous additional power gained. If we have a dry lens, our numerical aperture is evidently limited to the extent of the air angle —180°, or N.A. 1. But when water immersion was introduced, and still more when homogeneous immersion, the numerical aperture was at once increased to a very large extent. It may seem a paradox that we can get a glass to embrace a larger angle than 180°. At first glance this seems to bespeak looking round a corner, but the explanation is simple enough. We do not look round a corner, but in our angular aperture of 180° we include more pencils of light. If, for example, with a dry lens we can include 1000 pencils, we can with water immersion (by virtue of the higher refraction index of that liquid) include 1,300 pencils, and with suitable oils 1,500, while if we use not only suitable oil, but suitable glass for our condensing arrangements, we can, as already stated, reach to 1,600. But beyond this gain, immersion greatly improves the qualities of our objectives, it increases working distance, improves illumination, and mitigates the tendency to diffraction images.

Herein, then, lies one of the great advances made in our optical appliances. We vastly improved the performance and increased the range of our objectives by the immersion system. Amici seems first to have noted the beneficial effect of water immersion, but the system, I believe, was first carried into practical effect by Nachet or Hartnack. Mr. Wenham seems to have suggested but not used the homogeneous immersion system, and the great optician, Abbe, of Jena, worked out the matter and brought Wenham's idea to full fruition.

Oil of cedar, in virtue of its refractive index and its dispersion coinciding nearly with those of crown glass, is the oil generally used for homogeneous immersion. But it must be borne in mind that in order to get the full effect of this system, the objects themselves must be mounted in a medium of high refraction index, and this process is very apt to lead to error in observation. Mr. Nelson rarely photographs diatoms at any angle beyond the air angle, in order, as I understand, to avoid these errors of interpretation due to mounting objects in these media of high refraction indices. Unstained physiological tissues are often destroyed for observation by being placed in glycerine, and a piece of glass placed in a bottle of water is not in advantageous circumstances for examination.

I have now to touch on the latest and one of the great advances made, and this one affects in a very special manner our science of photo-micrography. On account of the nature of the glass used previously to but a few years ago, opticians found it impossible to correct objectives for more than two regions of the spectrum. Lenses were corrected for the blue and yellow regions, or perhaps more commonly for the green and red, and when using such lenses under conditions at all trying, we find fringes of color bordering our objects. In other words, we have a marked uncorrected residual spectrum. But Abbe and the firm of Schott working together at last succeeded in making glass with different refracting and different dispersing powers from the powers of glass previously made, and as a result Abbe has formulated and Zeiss has made objectives far superior in correction to any we have ever had before.

The photographic results are distinctly superior to those obtainable by use of more ancient objectives, and there is, moreover, a marked improvement in the images even for visual observation. Three spectrum regions at least are made practically coincident in foci, and the color fringes are, if not wholly eliminated, at least greatly reduced. Some English opticians have produced with the new glass—which, as has lately transpired, contains fluorspar—very good "apochromatic" glasses, apochromatic being the term used to describe this new phase of optical achievement. It is claimed that by use of this new glass greater numerical aperture can be obtained in conjunction with equally good or better general qualities, such as flatness of field, illumination, etc.

So far, I have mentioned *special* advances that have been made. I may now say *broadly* that the optical improvements consist of the attainment of larger angle without loss of general quality. I think I may say that the history of microscopic optics has been the history of numerical aperture. There always was and there ever will be a limit to the aperture possible with a given focal length, but now more than ever we are getting long focal length and large aperture conjointly.

In microscopic optics the word penetration must creep in sooner or later. Penetration or "depth of focus" is the suppositious power of focusing on two planes at right angles to the optic axis simultaneously, sufficiently accurately to prevent visible blur. It is manifestly impossible to focus on two such planes equally sharply, and the question is simply: How much blur is permissible? In artistic photographs it is a matter of taste, in scientific micrography it is a matter of mathematics.

Penetration decreases directly as aperture increases, but decreases as the *square* of magnification. It is therefore beyond argument that the more the aperture —and consequently the more the resolution—we can get with the least magnification, the greater will be the penetration we shall obtain, and therefore what we have to search for is an objective of low power, with as wide a working aperture as can be achieved without damage to the corrections and general qualities of the objective. With a given focal length opticians reach a point of aperture beyond which they cannot go without injury to the quality of the objective. That is where we shall always stand. But our standpoint will from year to year be pushed onward, and our optical appliances will from year to year improve.

Speaking for myself, I am well satisfied with the optical contrivances we have to-day, but I look with eagerness for some advance in photographic power. Particularly I long for greater power to cope with certain color effects and color combinations frequently met in my experience. I have no spark of doubt that in process of time every candid investigator of microscopic objects who wishes a graphic representation of his objects of study will employ photography as his delineator, and I maintain that the scientific investigator of scientific facts is bound to use for delineation the only scientific method of delineation—photography.

APPENDIX (*Objects shown in Illustration*).

1. Books.—*Bacteria*, by G. M. Sternberg. Second edition. 1885. *Photography of Bacteria*, by E. M. Crookshank. 1887. *Mikro-photographischer Atlas der Bacterien-Kunde*, by Fraenckel and Pfeiffer. Nos. 1 and 2. 1889. *La Chambre Noire et la Microscope*, by Jules Girard. 1869.

2. Prints, etc.—Collection by Dr. R. L. Maddox from 1868 and onward—diatoms, insects, silica films, etc. Diatoms by Thomas Comber. Diatoms, etc., by Dr. Clifford Mercer, Syracuse, U. S. A. Various objects by Mr. Rafter, U. S. A. Scrap book of bacteria, by A. Pringle, 1878 and onward.

LANTERN SLIDES.

Proboscis of blow-fly (lowest power to N.A. 0·90), four slides.

P. Angulatum	× 3000		Maddox 1868 or 1869.
"			
Silica film			
Navicula aspera	× 1000		Comber.
P. Angulatum	× 1000		
Cymbella	× 1000		
Isthmia nervosa	× 1000		
Coscinodiscus ossens	× 1000		

Triceratium × 80, × 375, and × 750 A. Pringle.

P. Angulatum	× 670	N.A. 0·7	¼" 0·9	E. M. Nelson.
"	× 1200	" 0·5	" "	
"	× 630	" 0·65	½" "	
"	× 1080	" 1·0	⅛" "	
N. Lyra	× 234	background	½" "	
C. Asteromphalus	× 2000	N.A.	⅛" "	
A. Lindheimerii		N.A. 1·38	⅛ Spencer	Van Heurck.
P. Angulatum	× 600	" 1·4	⅛ Apo	
A. Pellucida		" 1·6		
P. Angulatum		" 1·6		
"		" 1·6		
S. Gemma		" 1·6		
A. Lindheimerii		" 1·6		
A. Pellucida		" 1·6		
A. Pellucida	× 750	N.A. 1·4	⅛ Apo	Pringle.
P. Angulatum	× 2000	" 1·0	⅛ "	

Collection of bacteria, including actinomyces, cholera, typhoid, anthrax, etc.

APPARATUS.

1. Designed for the Royal Veterinary College. Made by Swift.
2. Baker's apparatus.

THE AUTOMATIC OPERATION OF PHOTOGRAPHIC APPARATUS.*

By Professor D. P. TODD.

THE need of automatic instruments has been more keenly felt in the prosecution of eclipse research than in any other department of scientific investigation where photography is an adjunct. I refer, of course, to the work which goes on during the total phase of a solar eclipse, which is usually only two or three hundred seconds in duration—when great variety of special problems necessitates a variety of instruments correspondingly great, and when the startling phenomena of the critical moments often occasion the hand to fail in executing a well rehearsed programme.

At the last total eclipse, visible in Angola the 22d of December, 1889, a novel combination of apparatus was for the first time brought into operation, and although clouds prevailed during totality, thus precluding the possibility of photographing the solar corona, the working of the apparatus was so successful that a description of it will not be without interest, in view of its possibilities in eclipse work in the future.

* Read before the Photographers' Association of America, at Washington, D. C.

In equipping the U. S. eclipse expedition to West Africa I recognized three essentials:

1. A great variety of instruments.
2. Large-scale pictures of the corona.
3. The necessity of perfect clockwork.

I saw no better way to meet these conditions than by making an equatorial mounting sufficiently capacious to accommodate all the photographic apparatus. Accordingly a split polar axis was built of six inch wrought iron tubes, about eleven feet long, and placed two feet apart. The whole was mounted English fashion on massive cast iron supports, capped with brass bearings. This was built by Mr. Saegmueller of Washington, and I was fortunate in obtaining from him the loan of a very perfect and powerful clockwork to drive it. This latter was in process of construction for the great equatorial refractor of the Denver Observatory, and I found its centrifugal governor, a triple twist flexible steel spindle, to perform with the highest accuracy.

Also, the means provided by Mr. Saegmueller for adjusting the polar axis into parallelism with the earth's axis proved to be very neat, and the adjustment was readily made so close that, with an hour's run of the clock, the declination error on the plate did not exceed 20".

On this axis was mounted all the photographic apparatus for the total eclipse, and a high power directing telescope to verify the pointing of the whole.

This comprised the following apparatus:

1. Professor Pickering's reversing layer spectroscope for photographing a spectrum trail for fifteen seconds both before and after second and third contacts.

2. Five photographic telescopes. The first a Clark 150/8 doublet, twelve exposures, two being through a Carbutt orthochromatizing screen. The second a Dallmeyer 38/6 portrait lens, sixteen exposures. The third a Dallmeyer 24/6 portrait lens, four exposures. The fourth a Ross 42/5 portrait lens, eighteen exposures. And the fifth, a Gundlach 22/3·75 aplanatic orthoscope, with one specially prepared plate for the extreme outer corona and other circumsolar objects.

3. Two catoptric telescopes by Brashear, with twenty-five exposures for each. The first having the ratio 33/8 with the central three inches of the mirror sacrificed to the plate holder, while in the second, 72/8, the entire aperture was made available by setting the plate holder at one side of the tube, and tilting the mirror slightly, as in the Herschelian form of mounting.

4. Five dioptric telescopes, with objectives uncorrected for the actinic rays. The first a Clark-Merz 96/6·4 objective, twenty-five exposures, of which five were made with the full aperture, and five each with apertures of 5, 4, 3, and 2 inches. The second a Schroder 22/6 triple objective, one hundred exposures. The third a Clark 72/5 telescope, with the sun's image enlarged to 4·5 inches diameter, four exposures. The fourth a Spencer 36/4 objective, eighteen exposures, divided among apertures varying from one to four inches. The fifth a Clark 49/3·5 objective, twenty-five exposures. This latter instrument was intended to provide pictures precisely comparable with those of the eclipse of 1889, January 1, taken by Mr. Barnard, and accordingly the aperture of the objective was capped down to 1·75 inches.

5. Two flint glass spectroscopes, and one quartz spectroscope.

6. Two duplex cameras for photographing the polarization of the corona.

7. A duplex telescope of 75 inches focal length for coronal photometry.

The finder, or directing telescope, was a 7¼ in. Clark refractor, with a high power eye piece.

In all, the apparatus mounted upon the polar axis embraced two mirrors and twenty-three objectives.

The operation of it by hand, as ordinarily, would, of course, have been impossible. My experience during the eclipse in Japan two years previously had suggested the desirability of automatic operation of all eclipse apparatus; and as a result of much experimentation with different electric and pneumatic devices, I finally ventured to adopt the pneumatic valve system covered by the letters patent of Mr. Merritt Gally.

By means of this unique and ingenious system, which has been largely employed in the automatic playing of musical instruments, a very small current of exhaust air, say of one-tenth inch diameter, is made to control an exhaust current very many times greater in volume.

A system of forty-eight such valves offered no difficulties of construction whatever, and was built in ten days' time under the immediate personal supervision of the inventor. The tubes leading from the valve ports were of half inch diameter. The control currents were governed by a succession of one-tenth inch apertures punched in a strip of paper about nine inches wide and seven feet long. This I wound upon the barrel of an ordinary chronograph so that it would unwind at a perfectly uniform rate when the chronograph was set going. As the paper left the barrel it passed over the "tracker" and was rewound upon a take-up roller. The whole was mounted over an exhaust organ bellows, strongly built and with springs of triple tension. This combined apparatus made a perfect pneumatic commutator, having forty-eight air currents in perfect control. In order to set any current in motion, it was only necessary to puncture the control sheet at a point whose x was equal to the time, and whose y corresponded to the number of the air port in the "tracker."

From the commutator, half inch lead pipes were run to the position of the different mechanical devices which were to come into action during totality. Here they were connected with small pneumatic bellows of the ordinary V-pattern.

Each bellows, then, was so connected by appropriate mechanical movements that its collapsing thrust should perform the various sorts of work required, whether the operation of an exposing shutter, the revolution of a nicol, the variation of available aperture, or the shifting of a photographic plate.

In such a variety of apparatus, it was impossible that one form of mechanical movement should suffice for the whole. The requirements of some of the instruments were best met by shutters which the pneumatic bellows held open against the action of a spring during the full length of the exposure; while others required that alternate sections of the pneumatic should open and close the shutter, or exposing slide. This was easy

enough; but the problem of changing the sensitized plates for new exposures turned out to be much more difficult, especially where a large number of exposures was required.

Where the plates were small and the exposures few, a sliding plate holder was found to work best. Here it was only necessary to fasten a ratchet to the back of the plate holder and then attach a pawl to the vibrating side of the bellows. But some of the plates were of the size 17 inches by 20, and they could not be advantageously managed in this way. I finally hit upon the idea of attaching them to a revolving crate or barrel, set in motion on its axis by means of a small weight fastened to a cord wound upon a pulley or wheel at one end. The whole was then rigged escapement fashion, with detents equal to the number of plates, and each detent so adjusted that when at rest its corresponding plate lay in the focal plane of the objective. A very small pneumatic then sufficed as a pallet, or as a trigger to set off the mechanical device on the conclusion of each exposure. This simple movement was found to be sure of action, easy of construction, and to require a minimum of time for shifting the plates. Also the capacities of other devices for shifting plates were tried. At the focus of one of the smaller instruments a plate was set in a small frame sliding laterally in a frame of twice its own dimension, and this latter again sliding longitudinally in a shallow box of twice the dimension of the outer frame. By means of three pneumatic bellows, appropriately set and fitted with ratchet movements, every part of the sensitive plate was brought to the center of the focal plane, and the exposure duly made.

For the reflectors, it was found best to employ an endless chain or belt of plates, double hinged together by means of continuous flexible tapes.

In order to test the utmost capacity of the automatic apparatus, and at the same time to furnish a large series of pictures of the same corona with a given instrument, a quick-acting lens was rigged with a long plate barrel, sliding automatically forth and back in a frame rigidly attached to the tube. The barrel had ten plate strips upon it, and the ratchet movements gave ten exposures for each strip. In this manner one hundred exposures, from a half second to two seconds long, were readily obtained with a single instrument.

In order to avoid the construction of a camera box for each telescope, I adopted the plan of mounting the polar axis near the middle of a large Ducker portable house, one end of which had a removable roof, while the other formed a dark room. The spaces between all the instruments in the axis were readily stopped, and a partition athwart the house was built up underneath the axis, and down from the rafters of the house.

It was then a simple matter to connect the partition with a wooden frame around the exterior of the polar axis, by means of heavy opaque cloth, secured to the partition and the frame, with sufficient slack to allow the necessary motion of the polar axis and all the instruments mounted on it.

It may be further stated that substantially all this apparatus was devised, constructed, and tested at sea, during the voyage of the U. S. S. Pensacola from New York to Saint Paul de Loanda.

Notwithstanding the evident impossibility of securing any pictures of the corona, as a thick cloud stood nearly stationary over the sun at the time of totality, the pneumatic commutator was brought into operation and the control chronograph set going fifteen seconds before the predicted time of second contact. The duration of totality was 190 seconds, and over 300 exposures were made. The automatic movements of exposing shutters and the other apparatus in the uncovered portion of the house were apparent, while in the absence of pictures on the plates, the accurate registration of the movable plate holders was rendered certain by the subsequent examination of marks so placed upon the slides and revolving barrels as to disclose any failure of the mechanism to act.

After many months of experimentation, it may now be said that the automatic operation of a large amount of photographic apparatus simultaneously has been carried beyond the experimental stage. Many of the mechanical applications which operated successfully at Cape Ledo might evidently be covered by letters patent, but their use will not be so restricted.

The simplicity and directness of the methods employed leave little to be desired, while the moderate expense of the apparatus puts it within easy reach. Of course, the equal facility of its application to the automatic working of every sort of physical apparatus will not escape notice.

THE PHOTOGRAPHIC NECKTIE.

Where will the progress of instantaneous photography end? In view of the admirable results obtained by scientists, and especially by Mr. Marey, inventors have for several years been setting their wits to work to devise small apparatus for allowing amateurs to take photographs without any one seeing them do it. We have already made known the photographic opera glasses and hat; but here we have something cleverer, and designed to meet with great success among practicians: it is a question of a necktie provided with a pin. The latter is an objective, and the necktie is a camera. When any one approaches you and speaks to you at a distance of 2 or even 3 ft., you press a rubber bulb concealed in your pocket, and you have the portrait of your interlocutor.

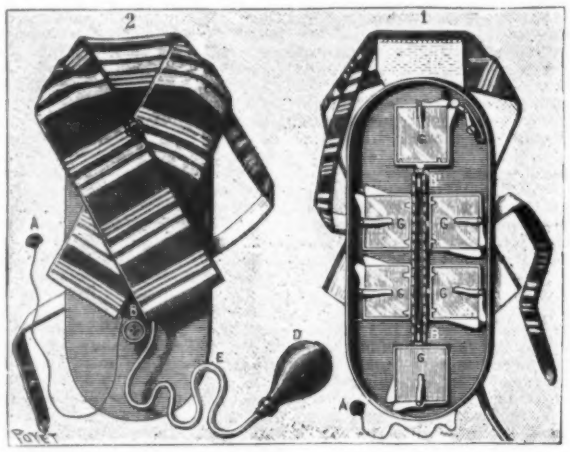
This ingenious little apparatus, with which also general views may be taken, was devised by Mr. Edmond Bloch, who has operated it in our presence, and, although the instrument is not yet being manufactured for sale, we have decided to make it known to our readers at once.

Fig. 1 represents the photographic necktie, and Fig. 2 gives a front view of it as it is to be worn by the operator, the metallic camera, which is flat and very light, being hidden under the vest. Fig. 1 gives a back view, the cover of the camera being removed to show the interior mechanism, comprising six small frames which are capable of passing in succession before the objective, and which permit of obtaining six negatives. The instrument may be constructed with 12 or 18 frames. The apparatus is operated as follows. The necktie having been adjusted, the shutter is set by a pull upon the button, A (Fig. 1, No. 2), which passes under the vest. In order to change the plate, it is necessary to turn from left to right the button, B, which has been introduced into a button hole of the vest, and which simulates a button of that garment. This button must be turned until the effect of a locking, which occurs at C (Fig. 1, No. 1), is perceived, and which puts the plate exactly before the objective. In order to open the latter, it is necessary to press the rubber bulb, D, which has been put into the trousers pocket. The rubber tube, E, passes under the vest and serves to transmit the action of the hand.

In order to charge the apparatus, it is opened at the bottom by turning the small springs, G G G; the sensitized plates are put into the frames, and the springs are turned back to their former position.

The apparatus is scarcely any thicker than the ordinary necktie called "Régate." The camera that contains the plates is not more than 0·2 inch in thickness. The six frames are carried before the objective through an endless chain, as shown in the figure.

Mr. Bloch has shown us some of the photographs that he has taken with this first apparatus, which he considers as yet but an experimental instrument. We reproduce herewith three portraits obtained with the apparatus, Fig. 3, through the minute objective skillfully concealed in the center of the pin. These photographs are about 1⅛ inch square, and are sufficiently sharp to allow the portraits to be recognized. If this apparatus can be well constructed, we predict a great demand for it.—*La Nature.*



Figs. 1 and 2.—PHOTOGRAPHIC NECKTIE—BACK AND FRONT VIEW.

Fig. 3.—FACSIMILE OF PORTRAITS OBTAINED WITH THE APPARATUS.

THE PHYSIOLOGICAL AND THERAPEUTICAL ACTION OF SULPHUR.

By John V. Shoemaker, A.M., M.D.

The mutations of medical practice as regards the employment of certain remedies is a fact no less curious on account of its familiarity. It might naturally be supposed that if a drug had been proved to possess valuable properties, it would never be suffered to fall into disuse. Such neglect, however, we do constantly observe.

New agents continue to be brought forward, more numerously of late years than ever before, and while it is true that some of these are valuable additions to the resources of the therapeutist, it is equally true that many are found to be destitute of peculiar power. Nevertheless, amid this crowd of claimants for favor, old and tried remedies sometimes fall into unmerited neglect. It is incumbent upon us, therefore, to critically survey from time to time the entire list of active medicaments.

We should seek to establish a consensus of professional opinion as regards the work of drugs. As practitioners, whose duty is above all to relieve suffering and repair the ravages of disease by all means within our power, it behooves us to examine our weapons, the drugs and the physiological remedies at our disposal, just as carefully as the quality, the sharpness of edge and antiseptic condition of our instruments and appliances prior to an operation in surgery. The more thoroughly physicians are acquainted with the manifold properties of the drugs they employ, the more successful are they in combating disease.

Among active medicinal agents few have been more completely neglected than sulphur. Few have less deserved neglect. In the hands of a preceding generation it was frequently and beneficially employed. The object of the present paper is to demonstrate that sulphur has a well defined field of usefulness, within the limits of which it can be surpassed by no other means.

It should seem that an element so widely distributed throughout the kingdoms of nature, an element which is a necessary component of the physical basis of all life, must play an important part in the processes of nutrition.

Sulphur is a constant constituent of albumen. It is present in from 1 to 1·6 per cent. in different varieties of albumen. Animal hair contains about 4 per cent. The proportion of albumen found in lymph is, according to Goup-Besanez, 24·6 in 1,000 parts; in chyle, 40·9; in blood, 195·6; in brain, 86·3; in liver, 117·4; in muscle, 161·8. A sulphur combination, sulpho-cyanide of potassium, exists in the saliva, while taurin, a normal component of the bile, contains a large proportion of sulphur.

From these facts of chemical composition we are led to suspect that sulphur may have a place as a remedy in the same category as iron and phosphorus; that is, as an element conducive to the health of albuminous organs and tissues. If sanguification be improperly performed, if the work of secretion be impaired, if elimination be checked, sulphur is one of the remedies which may be relied upon as a corrigent.

Sulphur is insoluble in water, slightly soluble in alcohol, ether and fatty oils. It is likewise soluble in the oil of turpentine and in the alkaline fluids. It is next to oxygen in its affinity to other elements. It unites with most of them and often in several proportions. When heated in the air it readily absorbs oxygen and is transformed into sulphurous acid gas. This latter compound, again, is gradually converted into sulphuric acid by exposure to air in the presence of water. The sulphites, in their turn, abstract oxygen from the air, and are converted into sulphates. Sulphuric acid exhibits a no less marked affinity for water, by virtue of which it exercises an escharotic effect upon organic tissues. These powerful chemical attractions by which sulphur is continually carried to higher combinations, with oxygen, are closely concerned with the absorption, therapeutic action and elimination of the element discussed.

The action of sulphur when directly applied to a surface is somewhat irritant. Yet it is marked by a more specific property, in that it is an energetic germicide. From these two qualities it is capable of use in a variety of accidents or diseases of the skin.

Wherever gentle stimulation is required, whether the affection be of a parasitic nature or not, sulphur may be properly and beneficially employed. Upon venereal sores, indolent ulcers, unhealthy or sloughing wounds, it acts as a stimulant and antiseptic. Its principal and external use, however, is the destruction of the itch-mite, together with its ova.

But it is not the external application of sulphur to which I am to-day desirous of calling your attention. I seek to present it in the light of a constitutional remedy having a well marked effect upon nutrition.

Being insoluble in the acid contents of the stomach, sulphur presumably exerts little or no influence upon the function of that organ.

Dissolved in the alkaline juices of the small intestine, a portion is absorbed under its own form into the portal circulation. Another portion enters the blood under the form of soluble sulphides. It has been conjectured that some is also absorbed after being dissolved in the fatty materials present in this part of the alimentary tract. If given in doses of half a drachm and upward, it is probable that a large proportion passes unabsorbed into the large intestine, and there combines to form sulphureted hydrogen gas, which is passed in considerable quantity by those who have taken full doses of sulphur. In some cases this gas appears to enter the blood and produces prostration and anæmia.

The secretion of the intestinal glandulæ is increased and the elaboration of healthy bile promoted by the comparatively small amount which is absorbed. At the same time that portion undergoing change acts as a stimulant to the muscular coat of the bowel. Thus the food detritus is softened and urged forward and the substance acts, as every one knows, as a gentle laxative. The depurative effect of the intestinal secretion, the antiseptic property of the bile, the depletory effect upon the mesenteric radicles, must be of valuable

service to the economy in certain conditions. Yet, as an illustration of the slight place which sulphur holds in the therapy of this country at the present time, I may remark that in Vol. II. of the System of Practical Medicine by American Authors, edited by Dr. William Pepper, treating of general diseases and diseases of the digestive system, two scant references to its laxative effects are all the notice which sulphur obtains.

After absorption this subsfance exercises a tonic, corrective or alterative effect upon many secretions. It is rational to believe that as it is conveyed to the liver, and as one of the peculiar constituents of the bile, taurocholic acid, normally contains sulphur, it must favor the bile-producing function of the organ. Taurocholic acid is a compound of taurin and cholic acid, and 25 per cent. of the former body has been found to consist of sulphur. That the administration of sulphur is capable of producing a beneficial effect upon the biliary function of the liver is seen in cases of inactivity of that organ, to which I shall hereafter more particularly allude. From a similar course of reasoning, I believe that the activity of the absorbent system is stimulated by the exhibition of small quantities of sulphur. The secretory functions of the skin and mucous membranes are modified or improved under the use of sulphur. The epithelial appendages contain normally a notable proportion of this element. In perverted nutrition of these structures I have often witnessed decided improvement from the administration of minute doses of the same substance, which, in such cases, may be looked upon as a specific nutrient remedy. It produces a beneficial effect upon the bronchial mucous membrane. It probably has a similar influence upon the mucous membrane of the genito-urinary tract.

A remedy which is connected with the action of the largest and most important gland of the body, which is closely related to the processes of secretion and excretion and probably to the function of the absorbent system as well, must have an important if obscure influence upon the quality of circulating blood. It must, consequently, minister to the nutrition of the muscular and nervous system. It has been stated that sulphur increases the power and frequency of the heart's contraction. While I can speak with no actual knowledge upon this point, and while I should not anticipate a direct or speedy action upon the heart, nevertheless I believe that its remote constitutional effects are to increase the heart's vigor. It favors, I think, the contractility of muscular tissue wherever situated.

A considerable proportion of sulphur is normally present in muscle, and must consequently be continually supplied to the tissue. Hence, in certain conditions the administration of sulphur improves the muscular health and tone. This being the case, it seems highly probable that cardiac contractility is promoted in the same way. The muscular coats of blood vessels, of the intestinal tube and hollow muscular viscera, as the heart, bladder and womb, should partake of the same benefits. With the improvement of circulation, the respiration should also be strengthened, deepened and quickened.

Now these constitutional results do not follow the use of sulphur as ordinarily administered. Of a full dose, a comparatively small proportion reaches the blood directly, but the larger portion descends the tube and is in the large gut a source of sulphureted hydrogen. This is a toxic gas, and although it usually escapes *per anum*, yet a small quantity may always be absorbed, since the prolonged administration of full doses of sulphur or a sulphide lead to emaciation and debility referable to the continued action of sulphureted hydrogen, which impairs the red blood corpuscles and depresses the motor ganglia of the heart.

The numerous chemical affinities of sulphur, its ready combination with the alkaline basis which it encounters in the small intestine, the ascending scale of its combinations with oxygen, blend the physiological and therapeutical actions of the elements and its compounds into an intricate study.

The interesting question arises, How does sulphur eventually do its work, and is it possible sharply to distinguish between the medicinal effects of sulphur, a sulphide, sulphurous acid, a sulphite, sulphuric acid and a sulphate? The chemistry of the blood is, indeed, a dark subject. All that I can say is that sulphur is readily converted into a sulphide, the sulphides and sulphites into sulphates, and that most if not all the sulphur eliminated by the kidneys is combined in the form of sulphates. Whether administered free or combined, it is probably always as a sulphate that it circulates with the blood, and the tissues of which it is normally a component are capable of separating and appropriating the element as needed.

Sulphur is eliminated by means of the secretions of those glands which it stimulates, the liver, skin and intestinal glands. It has also been found in the milk and in the respired air. It is chiefly, however, excreted by the kidneys as sulphuric acid in combination with alkaline bases, potassium, sodium or magnesium. From the skin and the lungs it escapes as sulphureted hydrogen. I have been in the habit for a number of years past of administering sulphur in quite small doses as a constitutional remedy, not only in diseases of the skin, but also in various affections of the alimentary tract, mucous membranes, muscular and articular structures, and in certain infectious disorders. It was consequently with great pleasure that I read the testimony to the same effect of the distinguished practitioner and writer, Sir Alfred B. Garrod, published in the *Lancet* for April 6, 1889.

The most obvious indication for sulphur is as a laxative in affections of the lower bowel. Accordingly we find that it has long enjoyed good repute in hemorrhoids when operative interference is forbidden. It likewise proves useful even in cases of bleeding from piles. It arrests bleeding here by unloading the engorged hemorrhoidal vessels, removing obstruction to the circulation, and allowing the propulsive forces an opportunity to act. In stricture of the rectum, the softened fæces produced by sulphur pass through the narrowed portion of the tube with less difficulty than more compact masses, while if the stricture be due to cancer, sulphur stools are less likely to occasion pain than those due to more active purgatives. For the same reason sulphur may be beneficially administered in fissure of the anus or anal fistula. It forms an appropriate laxative, also, as Prof. Bartholow has pointed out, after operations upon the pelvic viscera. It may not be generally appreciated, however, and yet it is not surprising, on reflection, that a very much smaller dose than that laid down in the books and generally employed is efficient, since, comparatively, so small a portion is absorbed. For the laxative power of sulphur is far more due to its action upon the glands and the muscular layer of the intestine than to the local effect of the unabsorbed portion. This, at least, is the conclusion to which one is led who sees regularity of alvine evacuation established by so small a dose as five or ten grains daily. It is to such small quantities, continued for a considerable period, that we are indebted for the systematic action of sulphur. If bulky doses be administered, much of it is lost, much of it combines with hydrogen, either in the bowel or the blood, to form a toxic gas, while the albuminous tissues cannot be forced to appropriate more sulphur pabulum than their needs require.

Sulphur will often prove remedial in a form of chronic sore throat associated with and perhaps springing from imperfect digestion. The patients are generally those who lead sedentary lives and habitually overtask their powers in monotonous labor unrelieved by cheerful recreation. The digestive and nervous system suffer, and various ills result either from nervous sympathy or a mild grade of toxemia. In such cases a change of habits, open air exercise, mental relaxation and small doses of sulphur as an alterative suffice to effect a cure.

The more closely the functions of the liver are studied the fuller must become our appreciation of its immense influence upon nutrition. It is true that in the processes of primary digestion, the bile seems to perform a less important and peculiar part than the gastric or pancreatic secretion. But in what may be termed the secondary digestion of albuminous material a further and no less necessary elaboration takes place by which unnecessary or deleterious nitrogenized bodies are separated in forms fit for excretion, and the crude peptones are transformed into the normal nutrient albumens of the blood.

We are ignorant, indeed, of the precise manner in which these changes are effected. It appears probable, however, that bile, absorbed from the small intestine and carried in the portal blood back to its place of origin, is intimately connected with the metabolism of albuminous substances. Now, in order that this work may be properly carried on, it is necessary that the hepatic circulation be active and that the bile be secreted in normal abundance and quantity. If this be not the case, we are all aware of the ill that results.

Digestive difficulties are perpetuated and intensified, inperfect preparation and separation of histogenetic and excrementitious products throw into the blood noxious materials which impair intellection, embarrass the kidneys, disturb the bowels, and eventually excite structural disease of heart, blood vessels or kidneys, hepatic or renal calculus, gout, and very possibly diabetes or carcinoma. It is the sluggish and overworked condition of the liver which serves as a starting point of this long train of evils, consequently the habits of life must be radically altered. This is the first necessary step in the right direction. Such hepatic torpor I have often found to be benefited by the prolonged administration of small doses of sulphur.

The cases which I have sketched are often hereditary, and the functional weakness would seem to point to a congenital insufficiency of the gland, as Dr. Budd many years ago suggested. Sir Alfred Garrod has seen wonderful relief result in a case of hepatic colic of many years' duration, from the use of a five grain sulphur lozenge persisted in for months. This is, indeed, removing the effect by striking at the cause.

If, as often the case, hepatic digestion be accompanied by constipation, a mercurial purge may fitly inaugurate the course of treatment on account of the promptness of its impression, but the systematic use of small doses of sulphur is less hazardous and more beneficial. Let me, then, ask my hearers when confronted with chronic ailments due, in their inception, to derangement of the liver—and we all know how extremely common these cases are—to think of sulphur given in small and what I may call tonic doses.

Sulphur is a gentle stimulant to mucous membranes. It is an excellent remedy in chronic catarrhal conditions. As the bronchial mucous membrane is the most frequently and constantly exposed to this process, it is particularly in chronic bronchitis and bronchorrhœa that the remedy under discussion is found most serviceable. Excessive secretion is checked, the sputum becomes more liquid and more easily ejected, and the cough, consequently, less frequent and less troublesome. The eminent Irish physician, Dr. Graves, in his clinical lectures, which are a model of style, and may, even after the lapse of so many years, be consulted with advantage, dwells upon the use of sulphur in chronic bronchitis. He tells us that his attention had been drawn to the value of this remedy in long-continued congestion of the bronchial mucous membrane by observing the happy effect attending the use of sulphurous waters, as those of Harrogate. He recommends it especially in the disease as it occurs in aged and debilitated persons with copious secretion into the bronchial tubes. It would probably be found useful in obstinate affections of other mucous membranes. Garrod suggests that it may be of service in cystitis, and perhaps in some disorder of the kidney. I think that it might very properly be tried in tubercular or gouty pyelitis and likewise in disordered menstruation when not obviously dependent upon serious organic diseases of the womb or its adoexa. As a normal constituent of muscular tissue sulphur claims attention as a remedial agent in disturbed nutritive conditions of that system. Such disturbance is usually due to the toxic influence of either gout or rheumatism. Not infrequently the outbreak of a gouty paroxysm is preceded by painful muscular cramps. Rhumatism often attacks the muscular system, and lumbago, torticollis or other myalgia refer the inquiring physician to a specific toxæmia. These muscular aches are often notably relieved by the persistent use of sulphur. Its applicability to the subacute or chronic muscular involvements leads one to think of making trial of sulphur when the same poison affects articular structures. In chronic articular rheumatism or gout the same method of treatment has been found beneficial. In rheumatoid arthritis, likewise, improvement results from the use of sulphur. Garrod tells us that it was in this disease he first employed small and continued doses of sulphur. He adds that he is doubtful as to what precise share sulphur may have in the benefit secured, since he has been in the habit of concurrently administering other remedies, such as iodine or arsenic. Reasoning by analogy, however, I have no doubt that sulphur is of decided therapeutic importance in cases of this nature.

This remedy is of value in acute infectious disorders. In diphtheria and the sore throat of scarlatina, the direct action of flowers of sulphur, which may be conveniently applied by blowing it through a paper cone, is decidedly antiseptic. It limits the spread of the membrane of diphtheria, destroys the micro-organisms upon which the growth of the membrane depends, and disinfects the organic product whose decay and absorption intensifies the blood poisoning.

A similar beneficial action is exerted in scarlatina, erysipelas, measles, and small pox. An ointment containing sulphur moderates the heat of the skin, allays the congestion or inflammation and disinfects the pus of variola. In place of sulphur itself, sulphurous acid may be applied to the throat by atomization in diphtheria, scarlatina, tubercular or syphilitic ulcers of the pharynx or larynx, and bronchorrhœa. Sulphurous acid and the sulphites have been employed internally in most of the infectious fevers and in puerperal septicæmia. We are obliged to confess the same disappointment with regard to sulphurous acid as of other germicides. They are not as effective within the human body as in the pathological laboratory. Nevertheless, certain of them do ameliorate, modify and shorten the disease which they are not able to abort. In fact, profound alteration of the blood, disturbance of the nervous system, the circulation, secretion and excretion, once inaugurated by a specific cause, cannot always rapidly subside even upon destruction of that specific and material cause.

Syphilis is another great general disorder which is, to a certain extent, influenced favorably by sulphur. We all know that in the management of syphilis much depends upon the functional activity of the skin. Hence baths and drugs which cause a slight determination to the integument, which heighten the respiratory and sudorific functions of that tissue, are important adjuvants to the more energetic antidotal treatment. Nothing is more unwise than a routine administration of mercury and iodide of potassium. There are times when such a course should be temporarily abandoned, and the patient placed upon simple tonics. Again it is always advantageous to occasionally suspend specific medication for a few days. During this period it is well to act gently upon the emunctories, and baths containing sulphide of potassium are very serviceable for their effect upon the skin. A resort to one of the sulphur springs may also be recommended, especially in cases of late syphilis and in debilitated subjects.

Sulphur baths and mineral waters have long been esteemed as curative in mercurial and saturnine intoxication. While they exert no attractive influence upon the metallic poison, they probably augment the effect due simply to temperature.

Sulphur has been used in tuberculosis. It often seems to have a good effect upon local tubercular lesions, though I have never been able to assure myself that it had any influence upon the generalized disease. Both sulphurous acid and hydro-sulphuric acid have been used. Sulphurous acid and its combinations are extremely valuable in yeasty vomiting.

Sulphur is a valuable remedy in many diseases of the skin. As it stimulates the depuration of the blood, the capillary circulation, nutrition and functions of the skin, as it enters into the chemical composition of the skin, the hair and the nails, it is not surprising that sulphur should be found of great service in many chronic cutaneous affections.

When seborrhœa is not obviously produced by frequently operative local causes, such as exposure to heat and cold, I have usually been able to detect some deterioration of the general health in its subjects.

Digestive ailments, exhaustion of the nervous strength by anxiety, overwork or excess; constitutional states, as scrofulous, tuberculous, anæmia, chlorosis, malaria, and other depressing influences, may be accountable for its occurrence. Except when it is associated with advanced phthisis, I have often witnessed marked improvement under the use of sulphur, especially in the dry variety of the affection. Nearly the same remarks may be made about acne, with the addition that it is peculiarly apt to develop in connection with the changes which take place at puberty. Manifestly, in maladies of which this may be said, no single plan of treatment is applicable to all cases. On the other hand, their common occurrence and their obstinacy compel us to the mastery of all our resources.

Sycosis betokens impaired nutrition, whether due to deficient alimentation or waste of energy from habits or disease.

Premature baldness and alopecia circumscripta are the result of impoverishment. The bulbs are shrunken, the shafts split and ragged. The condition may have been brought about by either local or general causes. In all these cases the internal administration of sulphur in small doses, and for considerable periods, has yielded admirable results, combined with appropriate topical treatment.

Chronic eczema is an inveterate complaint, and we are often obliged to run the whole scale of remedies before we find the effective one. Not infrequently this effective remedy will be sulphur. Again, boils, carbuncles, eczema and urticaria are among the manifestations of liver indigestion; general paræsthesia and the itching which often is attendant upon eczema may also be produced by the same cause. Here, then, we meet with a double indication for sulphur which acts at once upon the liver and the skin. And here, although something of a digression, I may call your attention to the virtue of sulphide of calcium in furunculosis. Given early, it will often prevent the formation of pus and cause resolution. But if suppuration be inevitable, the sulphide of calcium will, at least, limit its extent, favor its early evacuation and closure of the cavity.

In eczema, also, both of the acute and chronic form, I have found this sulphur combination beneficial. Malnutrition of the nails, expressed by hypertrophy, atrophy, or eczema, is sometimes amenable to sulphur in union with appropriate local measures.

Sulphur proves of avail in some of the most intractable maladies of the integument. In psoriasis it is of the utmost importance to secure functional activity of the skin, bowels and kidneys. This is effected by sulphur, and I have found it of use in psoriasis given internally, and also applied externally. Experi-

ence forbids us to expect much improvement in ichthyosis, scleroderma and lepra, yet some amelioration or at least arrest of the disease seems, in certain instances, to follow the administration of sulphur. The substance called ichthyol, which has recently been introduced into dermatological practice, and has been found efficacious in these same chronic affections, owes its activity, for the most part, to the large proportion of sulphur which it contains. Ichthyol is also, like sulphur, a most valuable topical medicament.

It has been my intention rather to invite your attention to the prolonged internal use of sulphur in small doses than to its local employment. Its use in scabies is time honored. It is excellent also in pediculosus, tinea versicolor, chronic eczema and psoriasis. Sulphurous acid is an admirable germicide, one of the best which we possess. It is used with the most striking success upon neglected and foul ulcers, and upon unhealthy wounds. It may be advantageously applied in *tinea favosa*. Dr. Schuster, of Aix la Chapelle, has devised an ingenious manner of applying it to the scalp. A net of strings is stretched across the lower third of a card-board box which fits to the head, and can be closed by a lid of the same material. A saucer containing burning sulphur is laid upon the net of strings and the box covered. The patient must sit still for half an hour. An abundance of sulphurous acid gas is generated, the sulphur ceasing to burn, of course, as soon as all the oxygen is exhausted.

Some doubts have been thrown upon the value of sulphurous acid as a disinfectant by the experiments of Koch and Sternberg. These, however, related to the power of the gas in disinfecting apartments and large masses of material, such as contaminated rags in bale. The gas was rapidly lost by diffusion, and was found to have slight influence upon dry stores Nevertheless, it deserves to be ranked high as an antiseptic to moist cultures or under the conditions in which micro-organisms develop in human tissues.

My remarks have applied for the most part to uncombined sulphur. The ready combination of the element and the ready conversion of sulphites into sulphides establish a close community of the therapeutic action between sulphur, sulphides, sulphurous acid and the sulphites. Sulphuric acid and the sulphates exhibit diverse properties.

I have been accustomed to administer washed or precipitated sulphur in milk or in capsules. Garrod gives it in the form of a lozenge containing five grains of the milk of sulphur and one grain of cream of tartar. —*Dietetic Gazette.*

THE SAHARA DESERT.*

The arid regions of the world are, speaking roughly, distributed in two bands north and south of the equator. They comprehend all inland drainage areas, or areas where the streams have no connection with the sea, which are also regions where evaporation is in excess of precipitation, for if the latter were in excess the water would rise till it could flow into the sea, as in the case of the great lake region of North America, and the area would no longer be one of inland drainage.

The largest of the deserts, the Sahara, is about 3½ million square miles in area, and the area of all the deserts of the world together about 11,500,000 square miles. In other words, over one-fifth of the land of the world has no outlet for drainage to the sea, and in all that area evaporation is greater than precipitation. These areas correspond very closely with the regions of the world where the rainfall is less than 10 in. annually.

In no place in the world can there be found such enormous ranges of temperature as in these deserts. In the Sahara the temperature sometimes falls from 100° during the day to the freezing point during the night, due to the great dryness of the atmosphere and to the radiation that takes place from the soil after the sun has set. These inland drainage areas correspond very much in their barometric phenomena. In all desert regions during summer all the winds blow in upon them. In winter the reverse takes place—the winds flow out of them; and that holds good both for the northern and the southern hemispheres. This occasions the low rainfall, for the great majority of these regions are more or less bounded by high hills. The winds arrive at the deserts over these hills, and the vapor is precipitated from the atmosphere by the hills, with the result that when the winds reach the interior regions there is nothing left to be deposited. If there are not hills all around any desert area, then, as in the case of northern Asia, the winds pass from a colder to a warmer climate, and as they get to warmer regions they are able to contain more vapor, and consequently no rain is precipitated.

The author then gave an account of his own views and impressions as to the Sahara. When staying in May last in Algeria, he was anxious to make a trip to the desert, principally with the object of examining the sand and other deposits. During the Challenger expedition they had found in the bed of the Atlantic for a long distance west of the African coast opposite the Sahara, and in the bed of the Indian Ocean to the south of Australia, small grains of red quartz sand, and they had found scarcely a trace of such in the seabed in any other part of the world. He suspected this quartz sand had been blown out from the Sahara in the one case and from the Australian desert in the other.

In the south of Algeria he got a light carriage which could traverse the desert, such as was now in use for the post just established by the French to Tougourt, in the Sahara. Taking bedding and food with him, he first skirted a large area covered with salt, and then passed on through the long belt of oases which the French have planted on the way to Tougourt. Along this route numerous artesian wells had been sunk, and an abundant supply of water thereby obtained for the palm trees which had been planted. There were now three companies in existence, who had dug artesian wells, and were planting thousands of palm trees, with the view of getting a valuable return in a few years.

At Tougourt the real sandy part of the desert began, and he made excursions into it, with that town as his headquarters. He exhibited to the meeting a specimen of the sand, of a light yellowish brown color, and exceedingly fine in the grains. There were a good many clay particles in it, and the quartz particles, which were also numerous, were identical with those they had got in the bottom of the Atlantic. There was no doubt that the winds from the desert carried the sand a long way out to sea. He had also examined the region geologically, and the formation of the rocks was entirely that of fresh water, and of Quaternary date.

The great majority of geographers and geologists had expressed the belief that the Sahara was an old sea bed, but he was of opinion that it had never as a whole been covered by the sea since Cretaceous or Devonian times, and no part of it had been covered by the ocean since Tertfary times. All the assertions as to the discovery of shells rested upon one common species being found very rarely in one region of the desert. He thought that, owing to recent researches, the opinion as to the Sahara being an old sea bottom was likely soon to disappear from our text books. He considered that the features of the region had been produced by atmospheric conditions. The sand was the product of the disintegration of the rocks *in situ* which engirdle the Sahara. The existing rock was not far below the surface, and by digging down to it, the hard, sandy particles were found embedded in the stone. The sun shone on the rocks, and they expanded. The sudden cooling at night broke them up, the wind carried away the smaller particles, and so continually the rocks were being disintegrated by means of changes other than water, although water perhaps had in times past played a greater *role* there than it did now.

There was a range of hills in the desert to the south 7,000 feet high, and for three months in the year their summits were covered with snow. Descending the hills were river courses, some of great length. Much of the region, he considered, had once been a large fresh water lake. Speaking of the commercial aspect of the Sahara, he said it was difficult to go there without becoming enthusiastic about it. There seemed to be no limit to the amount of water that was to be got by sinking artesian wells. The head of the water must be a long distance away in the higher lands surrounding the desert.

The cultivation of palms was extending to an enormous extent, and the French expected to carry on their railway to Tougourt (at present nearly a week's journey from Algeria) in the next few years. The French were also hopeful that France would tap all the trade of the North Soudan across the Sahara, by making a railway across the desert. He did not think it was at all impossible to build and keep open such a railway. There was plenty of water to be had, and the sand never drifted to such an extent as to bury a railway. The climate, though very warm, was at the same time very healthy. If the French built the railway, they would then have no cause to complain about Britain remaining in Egypt.

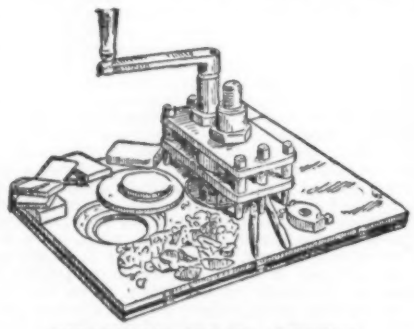
* Abstract of a paper read by Dr. John Murray at the meeting of the Scottish Meteorological Society, held in Edinburgh, on July 14.—*Nature.*

A BURGLAR'S KIT.

The ingenious methods employed by thieves to overcome the obstacles that are set in their way to thwart their nefarious schemes are surprising and show a large degree of mechanical skill. Bolts and bars are brushed away as if they were merely wisps of straw. Simple devices to protect property are overcome by simple means; but when the appliances are intricate, scientific and supposed to be invulnerable, the enterprising burglar rises to the occasion and quickly demonstrates that the idea of safety is a delusion.

Burglars keep pace with the times. Improved methods of protection are met with improved systems of burglary. Inventors burn the midnight oil in building strong boxes where money, jewels, and bonds can be placed without danger of being removed by nightly visitors, and the burglar studies just as hard to find the weak spot in the box.

The many successful robberies that are planned and executed constantly show that the thief has much the best of the argument, and that the tools employed in his trade are more than a match for inventive genius backed by science. Men who make a business of robbery are not idle during their leisure moments. Besides keeping an eye upon the police, they are ever on the watch for short cuts to plunder. They do not want to be bothered when out on a job by running



BURGLAR'S PLATE CUTTER.

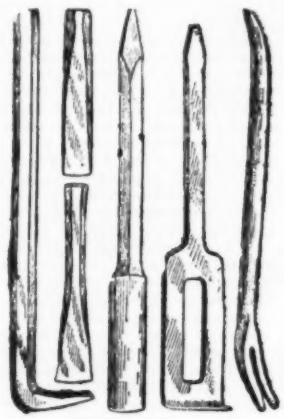
across a new obstacle in the shape of an improved bolt, lock or fastening, to get rid of which might delay them so as to interfere with the success of the work.

One successful means of avoiding these tantalizing delays is the Patent Office reports. No lawyer scrutinizes the monthly reports more carefully for infringements than the skillful thief. He studies every mechanical device for the better protection of goods and chattels with a critical eye, until its virtues and defects are a fixture in his mind. He does not complain to any court about the infringement on his rights, but takes the law in his own hands and puts a permanent injunction on the patent by knocking the invention sky high when the interference is brought to his notice professionally.

Burglars are excluded from polite society, and yet they are in a way public benefactors. Being practical communists, they believe in a division of all worldly goods. Having nothing themselves, they seek from others enough articles of value to give them a fair show and standing in the community. The public does not share their belief, and mildly protests by shutting itself up with its property with bolts, bars, and fastenings all around. The manufacture and sale of these goods afford a splendid investment for capital, and thousands of workmen are employed in factories making locks, bolts, keys, and other useful things, and in stores selling them, who, if it were not for the progressive burglar, would have to seek other and perhaps less congenial fields of labor.

Robberies occur more frequently than the public have any idea of, because the police have, in this city at least, adopted the policy of keeping the facts secret until after an arrest has been made, and it is only when the knowledge leaks out accidentally that it is gained.

Though the midnight intruder makes his rounds with great regularity and depletes the private treasury to a greater or less extent, there are comparatively few



JIMMIES.

persons who have any idea of the manner in which thieves work, and of the ingenuity displayed in carrying their schemes to a successful issue.

Burglars, as in every other branch of mechanical industry, have to serve an apprenticeship and learn their trade. They do not go up the ladder at a bound, but step by step, and if they have the requisite qualities and do not spend too much time in jail, may get a world-wide reputation as first-class experts. Thieves, according to Inspector Byrnes, like poets, are born, not made, but they have to be trained and instructed in the rules and regulations of the business. There are no salaried professors in the burglars' academy, the expense of the education being defrayed by a regular assessment upon the public treasury. There are grades in the business, and the lowest order is the house sneak thief.

This class is made up of the young thieves who are just starting on the rosy road to glory or to jail, and the superannuated thief whose usefulness in other fields is over. The old thief is the instructor, and bends the sapling in the right direction. The young man does the work and divides the "swag" with his partner. There are rarely more than two in this branch of the trade, principally because the profits are small, though frequent changes are made in the partnership.

Sneak thieves gain an entrance into houses either by force or fraud. In the first case the point of attack is almost invariably the front or basement doors. They are not really in the class of house breakers, although they may force an entrance. A favorite method is based on the carelessness of housekeepers who do not secure the outer doors. The thief, with rubber soles on his shoes, will go from house to house early in the evening hunting for a door that is unlocked. He opens it noiselessly, enters the hall, and perhaps the room opening upon it, grabs quickly whatever is in sight that can be carried away without attracting too much attention, and disappears with his booty. He usually takes clothing, silverware, and ornaments. He dresses well and might easily be mistaken for a member of the household by a stranger. At the time when these thieves work, doors, if they are locked, are not bolted, and the thief, watching his opportunity, will open the outer door with a false key or pick lock. They take few chances, rarely go up-

RATCHET DRILL.

stairs, unless they get into a house in the summer, when the family is away.

Sneaks, after their spines have become stiffened by experience, boldly enter houses under the pretense of being agents, canvassers, plumbers, health inspectors or something else, and, if they get a chance, will steal anything they can reach, even if it is of trifling value.

They have generally to deal with women, who are usually unsuspecting and become accomplices without knowing it, and often make a rich "haul" in the shape of diamonds and other jewels. Flats afford an excellent opportunity for these impostors to exercise their talents. An easy entrance is made into the halls, which communicate directly with the living rooms, and the presence of a stranger in the house would not excite suspicion. Even if they are questioned, the names on the letter boxes in the vestibule give them a ready acquaintance with the tenants that often

serves to divert suspicion. Police station blotters are filled with complaints of these robberies, but the thieves are rarely caught. They change their base of operations daily, so as to throw the police off the scent.

What are known technically as second story sneaks are those who make a specialty of entering houses through the windows in the upper part of the building, and never through doors. They are cunning fellows, their method of work is dangerous to life and limb, and they often get severe falls from a height of fifteen or twenty feet. Two of them generally travel together. One "plants" the house and the other does the work. In order to make these robberies successful, the habits of the family are carefully studied. The job is done early in the evening. The turning up and down of lights are tell-tales to the watcher. A house is selected by the "planter" as he saunters through

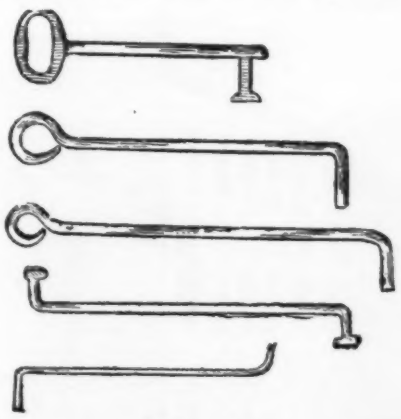
SLEDGE HAMMER AND WEDGE.

the avenue which is favorable for this sort of work, that is, one that has a portico or rear extension that can be scaled. The question whether the job is worth trying or not comes up, and this is answered by the presence or absence of sparkling gems in the ears or on the fingers of the women of the household. If the invasion gives promise of "panning out" richly, then the occupants of the various rooms are picked out by watching at night. The dinner hour is carefully noted, and what the servants are in the habit of doing at this time.

When this student of domestic life is satisfied that the upper part of the house is unprotected and vacant at a certain hour every evening, the "worker" is called in. He has an expert eye and picks out the easiest place to climb, either in the front or rear. He is usually a young, supple, and athletic fellow, and wears either rubber-soled shoes or shoes with sharp, short spikes. When the clatter of dishes is heard and the family are quietly enjoying their dinner, the thief climbs quietly to the second story window by the selected path. The windows of these rooms are rarely locked and the thief has no trouble in getting inside. Then he loses no time, but moves with lightning speed, as quietly as possible. Small articles of value are picked up, and in the sleeping apartments rings, earrings and watches that have been carelessly left on bureaus or in exposed jewel boxes preparatory to being worn in the evening. The plunder is put into a small cloth bag, and when the thief thinks it time to take his departure, he tosses the bag to his confederate on the outside. The exit is usually made through the front door, unless the intruder is surprised at work, when he will slip out of the window as he entered with the agility of a monkey. The front door when the thief goes out is always left ajar, so as to make it appear that the entrance was made in this way. This is done for the benefit of the police, to direct their attention to sneak thieves instead of second story men.

The thieves are generally well rewarded, and as much as $40,000 worth of jewels has been taken from one place. Servants are often suspected of committing these thefts, and in some instances have been unjustly punished.

Quite distinct from this class is the hotel sneak thief, who is a clever individual with the outward appearance of a gentleman of wealth and leisure. It is in this work that the thief begins the use of tools. It is easy enough for the plunderer to enter a hotel as a regular guest and to put down his name in the register with all the assurance of honesty. Then he gets "the lay" of the interior of the hotel, acquaints himself with the names of his fellow tenants and their business, and pays special attention to those who let their money fly over the counter in the barroom. Stimulants make men wide awake and jolly; they also make them good sleepers, and the work of the thief easy and safe. Hotel keepers protect their rooms with locks and bolts, and have hall boys, porters and watchmen detailed to watch the guests and their property during the day



SKELETON KEYS.

and the silent hours of the night. But bell boys, porters and watchmen, quieted by a feeling of security, sleep away the passing hours, and often only hear of a robbery hours after it has occurred.

All the large hotels in this city employ detectives, who are familiar with the faces of the noted "crooks," and keep an outlook constantly for suspicious persons. The thief is usually smarter than those set to watch for his appearance, and usually outwits them all. He sometimes gets into rooms under the cover of friendship while the occupant is tipsy, and helps himself to whatever valuable articles are handy. The doors of the rooms in hotels are alike, and the thief knows precisely what he has to meet, even if he has never been in the room which he intends to visit. Any time of the day or night suits him; all he is looking for is the opportunity. The thief, being satisfied that he has a clear field, goes directly to the room from his own with cat-like tread. He finds the door locked and bolted. The lock is quickly turned with a false key.

Occupants of rooms delude themselves into a feeling of safety by leaving the key in the door on the inside, thinking that no other key can be used. The thief is ready for this emergency. He takes a small pair of nippers from his pocket, having slender, grooved jaws which fit over the projecting end of the key and enable him to turn the key as readily as if he had hold of the handle. If there is a bolt on the door, it is usually a few inches above the keyhole. The thief shows his cleverness in reaching it. The key in the door has to be got rid of, and this is done by slipping a piece of twine around it with the nippers and pushing it out of the hole and lowering it to the floor without making a noise to awaken the sleeper. If no one is in the room, it is pushed out at once.

A fine steel wire, which can be bent double without breaking, having an eyehole in one end through which is passed a strong cord, is shoved through the keyhole. By holding the cord firmly and pushing the wire slowly through the hole, the wire is made to form a loop which is twisted in an upward direction until it is caught upon the projecting knob on the bolt. Then it is an easy matter to slide the bolt by tugging gently on the wire. If the knob is in the socket on the upper side of the bolt, the wire loop draws it into the proper place to move the bolt. The loop cannot be worked if the knob is in the slot on the under part of the bolt.

The thief enters the room, takes whatever of money, watches and jewels he can find, and vanishes. To divert suspicion he returns the key to the lock and turns it with the nippers from the outside. Hotel robberies are common, but are not often reported to the police because the losses are not heavy enough to inconvenience travelers, who do not care to be bothered and delayed by the tedious proceedings of criminal courts. Hall boys are often in league with thieves, and get a share in the proceeds.

THE POWERFUL "DRAG."

The biggest and brainiest of all thieves in this class is the bank sneak. No tools are required in this except the native ones of courage, agility, an outward appearance that awakens confidence, good credentials, and that peculiar trait which gives men the power of impressing others with being what they are not—this is the stock in trade of the confidence sharp. There is no more daring thief in any branch of the art than the bank sneak who "goes it alone." He enters the bank with a gripsack or paper package in daylight, when the officials are all busy with their work, and the place is filled with customers. He has a bank book in his hand, out of which stick the ends of some blank checks. He gets on the end of the line, generally about 1 o'clock in the afternoon, and adroitly manages to stay there until he reaches the cashier's or paying teller's window. He does his work while this official is busy with the customer in front of him. The package or the valise is only a soap box which he drops on the floor. Giving a quick glance everywhere to see that the way is clear, he steps on the box, reaches over the railing, grabs as many bills as his long fingers can encircle, leaps lightly to the floor, and is out of the bank before the cashier has had time to close his mouth and eyes and recover his senses. These thieves are built for the purpose, being tall, slender, strong, and wiry, and when they reach the street the fastest sprinter on the cinder path would have to follow their heels.

The money is put into a bag concealed under the coat to hide the object of flight, and by dodging in and out of the crowds, among trucks and around corners, the thief usually gets away. Partially to recompense the bank, the thief leaves the soap box behind.

Large banks have special watchmen, clerks, and high iron railings to guard against the soap box operator, but he ingeniously conceals his identity and sweeps through them all like a cyclone.

The bank sneaks who despise the soap box method as much as they do a pickpocket go in gangs of three or four, and are looked upon as the gentlemen of the profession. They must have all the outward marks of respectability, because they have to deal quietly and peaceably with the bank officials personally. They are made up of the outlook, who hoists the danger signal, the confidence man, who does the talking and makes the excuse for their presence, and the "worker," who goes off with the cash box. These thieves are quick witted and take advantage of every circumstance that will make their scheme successful. They visit banks in the day time, and the outlook posts himself where he can get a good view of the street and the bank. The confidence man, who is of excellent address, by some plausible scheme, that may either be the work of a moment depending upon a sudden emergency, or a carefully prepared one, engages the attention of the cashier while the worker slides into the vault and secures whatever money he can pick up in a second. The worker is a slippery fellow, and has been known to go through a room filled with clerks, going over their books to the vault, and help himself and go out again without being stopped. The risks that they will take are amazing, and after it is all over, and the thieves have driven away in a carriage with the money, everybody wonders how it could have happened.

The city banks are so well guarded that the bank sneak has little show, but in the country there are thousands of places where he can keep his talents from getting rusty. To "hold up" a bank at the point

NIGHT PROWLERS' WEAPONS.

of the pistol requires only brute force, but to talk an armful of money out of the institution requires sublime assurance and a gullible banker, and shows what a many-sided thing human nature is. Sometimes where the job is a particular one the thieves study the bank for weeks, watch the movements of all the officials and clerks, get acquainted with some of them, find out all about the work of each one, and the time when they usually get to the bank, eat and leave, and, if necessary, will open a small account and collect interest later at a usurious rate.

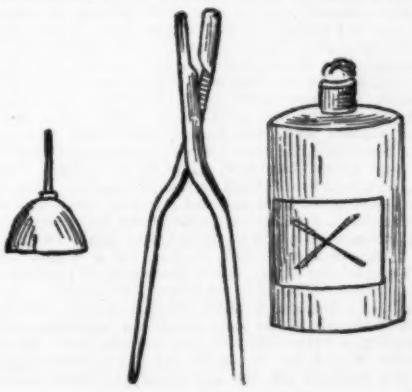
Rube Minor, the most successful and dangerous bank sneak that ever lived, set the example of what a thief of this class should be. He was always a gentleman in deportment, would not deign to strike any one or use force to obtain money; but his old companions, "Big Jim" Burns, John Jordan, "Georgie" Carson and "Many" Marks, were not always so gentle.

After having sufficient experience a sneak or general thief may develop into a burglar, provided he has never been kown to "squeal" and can make the proper connection with the gang. It is in this line that the thief displays his mechanical taste and skill. Every burglar of standing has a "kit" of tools. They are made usually by a mechanic who is a member of the gang, or an outside machinist with an elastic conscience who asks no questions. A "kit" will cost several hundred dollars.

An outfit is made up of jimmies, drills and punches, clamps, jacks, sledgehammer, brace and bits, ladder of rope or steel wire, wedges, chisels, air pump, powder and oil can, plate cutter, skeleton keys, and clubs and weapons of assault and defense.

The ordinary housebreaker uses only a part of these tools, and works in the night. Houses only are attacked where the prospect for plunder is good. This information is gleaned from the newspaper accounts of weddings, balls, dinner parties, and advertisements, by watching the houses and from gossipy servants. A window is preferred to a door as a means of entrance, as it is easier to open. Sometimes a room is hired in one of the houses in a row, where the roofs are level, and the thief gets in through the scuttle. A wooden shutter is opened by forcing it with a small jimmy, or by pushing back the catch with a steel blade that is extremely pliable. In iron shutters the position of the bars is shown by the bolts, and by boring a hole near them and using a small wire they can be drawn. The window fastening is shoved back with a thin blade. Where patent catches are used, the glass is cut with a diamond point in a small circle, within which a piece of wet leather is firmly pressed with a string attached like the boys' sucker. A light tap or jerk breaks the glass and the sucker prevents it from falling. This gives access to the fastening. When there are iron bars on the lower windows the burglar goes to the next story, which is reached by a flexible ladder with hooks on one end. This ladder is raised to the window sill by being thrown, or with a pole.

Two thieves generally enter together, and one or more guards the outside. One burglar packs the plunder into a bag, while the other watches for squalls.



NIPPERS AND CANS.

They do not waste any time, and go from the cellar to the garret. They hunt in out-of-the-way places for jewels, and this explains why watches and other things that are in plain sight are sometimes overlooked. When in a room where there are sleepers, one thief will stand by the bed with revolver and club ready to be used. Care is taken not to flash the search light or dark lantern into the sleeper's eyes or out of the windows. Medical experts differ in opinion as to whether or not an anæsthetic can be given to a person asleep without arousing him. Burglars have only one opin-

ion. They have often used chloroform successfully and can attest its value. Burglars have learned by experience that fright keeps people quiet, and if any one awakens, they try to scare him into keeping still by threats.

Burglars when working never call one another by their right names, and often wear masks to prevent identification. They are not afraid of men, but a frightened woman and a young child keep their nerves on a ragged edge. A woman is likely to scream at any stage of the game, even when her silence is enforced by the muzzle of a revolver at her temple. Unaccountable noises, however slight, test the burglar's courage, and "Long John" Garvey, who was in the first rank of thieves, once jumped out of a window and broke his leg in Lexington Avenue, at the sound made by a cat stretching its claws in a carpet. Housebreakers will take anything of value that can be easily sold, but have a natural preference for money, watches and jewels. They have murder in their hearts, and will kill rather than be caught and serve a long sentence.

Old burglars say that they would rather meet an army of men with clubs than go into a house where there is a small cur that will not take meat from a stranger's hand, but will keep up an everlasting barking.

The king pin of thieves is the bank burglar. Out of the ranks of general and special thieves there will blossom forth one who is better than his fellows in intelligence, courage and mechanical skill, and a number of these congenial spirits make the bank burglar's gang. They are tried and true. The gang is not the work of a day, although there are only four or five in it, but a leader has been known to let years go by in picking out his associates for some special job. True worth must have been shown by acts. Bank burglars detest "squealers," and any one who gives information to the police forfeits his life.

The leader generally selects the bank to be attacked. Plenty of time is given to the preliminary work. It is known that "Jimmy" Hope "planted" a bank, perfected the plan of robbery and waited twenty years to find the men that he would take into his confidence. He was rewarded with success.

An entrance to the bank is made in many ways, depending on the surroundings. If there is a watchman he is either bribed, drugged, killed or got out of the way by strategy. Rooms are often hired adjoining the bank, and a restaurant or shoe store opened. This gives a chance to dig through the walls without suspicion. The habits of all connected with the bank are carefully studied, and friendly intercourse established if possible. The site of the vault, the safe maker, the kind of lock and the manner of getting into the safe are all known beforehand, so that when the thief gets into a bank with his "kit" there is no delay. The time selected to "crack" a safe is generally between Saturday night and Monday morning.

For over a hundred years there has been a contest between the safe makers and the safe breakers. It has been a battle royal, and the thief has always had a little the best of it. There have been brains on both sides, and it has always made the safe maker sad to see the door of his burglar-proof safe, which it took him years of study to perfect, fly open in about twenty minutes after his natural enemy got to work on it. The burglar has kept the safe maker busy by pointing out the defects in construction. Every safe that is "blown" means a new safe from the maker, and thieves, to save labor for themselves, do not attack a new safe until a large number have been sold. Burglars get possession of every new lock by fair means or foul, and the defects are noted for further use.

There are many methods employed by burglars to open a safe, depending on the way it is put together. Their object is to break down and unloosen things. In the old "knob" safe, which was covered with bolts connecting two iron plates, powder was blown through the keyhole and the door lifted from the hinges by explosion. Then the keyhole was hidden in one of the knobs, but the burglar did not look for it. He made a hole in the door with a drill and put in the powder. Safes were made with bolts in the door that could be sprung into the framework on all sides with a spindle connected with a T handle on the exterior. This was thought to be a puzzler to the burglar, but this mechanical genius knocked off the handle with a hammer, softened the spindle with a lamp and blowpipe, drilled it out, put in the explosive which carried away bolts, framework and all. Safe makers defied the burglars by making a safe of alternate layers of iron boiler plates and drill-proof steel, hardened so that they would turn the edges of a drill. The burglars taught the safe makers a lesson so quickly that it made them dizzy.

The burglars invented the plate cutter, a powerful tool, but did not patent it. Holes were bored in the outside iron plate of the door, and the cutter was fixed in place. The blade of the cutter was kept well oiled, and the handle was turned until a round hole was cut through the iron plate and the disk was removed. This exposed the first steel plate. This plate was extremely hard and, therefore, brittle; and, the cutter being removed, the steel was easily broken with a chisel and soft metal hammer. The metal would resist a drill, but could not stand repeated shocks. The alternate plates were thus cut and broken until the bolts were reached, and the safe could then be opened easily. Then safes were made to defeat the plate cutter, and the burglars abandoned its use for a while. They tried something easier, filled the cracks of the safe with putty, except at the top for about two inches. At this point was attached a tube from a pump, which exhausted the air in the safe, created a vacuum, and by removing a little putty in the bottom crack as much powder would be blown in by the air rushing in to fill the vacuum as was necessary to blow open the doors.

On the portable burglar-proof safes the doors are opened without explosives by stripping off the iron bands with clamps and jimmies and forcing wedges into the cracks with a powerful jackscrew. The first wedge is like a knife blade, and the size is increased until the door flies from its hinges. Another tool is the "drag." This is a heavy steel bar upon which a thread has been cut, and it is operated with a stout handle, five or six feet long, to give great leverage. A hole is first bored through the door or back of the safe. A thread is cut in the plate to correspond with that in the "drag." The tool is turned until the opposite side of the safe is reached. When a great pressure is put on the long handle, something will have to burst. It is usually the door. Sometimes, when the doors promise a hard task, the burglar reaches the top of the safe and bores a hole there to introduce the powder. Fireproof safes are about as troublesome to a burglar as smoking a pipe to a sailor, His tools go through the metal and other material like old cheese.

It was thought when the time lock was invented, which unlocked the doors automatically at a certain time, that the burglar would have to "take a back seat." He was quiet for a brief period, and kept his experiments secret. Then, all of a sudden, time locks safes began to fly open all over the land. The burglar had discovered that by exploding dynamite on the outside of the door over the clock, the door would bulge in, and the force of the shock would break the spring or disarrange the mechanism so that it would run down and turn the bolts. The same thing happened in clocks that were constructed to unlock the safe when stopped. The burglars had an easy time with time locks on doors, because it has been shown that dynamite beats them all. When a heavy charge of dynamite has been used, the lock has been, in several cases, blown entirely off the inside of the door.

One of the cleverest pieces of work done by burglars is picking combination locks. There are few who can do it. It is done by the sense of touch and hearing, after long practice with locks of every style.

With all the inventions that have been made, it is admitted that there are no safes that are absolutely burglar-proof, provided time enough is given to the thief to work at them. The object of safe manufacturers has been to keep thieves from getting through the doors between Saturday night and Monday morning, and this has been done by massive blocks of metal and stones, surrounding the vaults, with all kinds of alarms and watchmen armed to the teeth. —*N. Y. Tribune.*

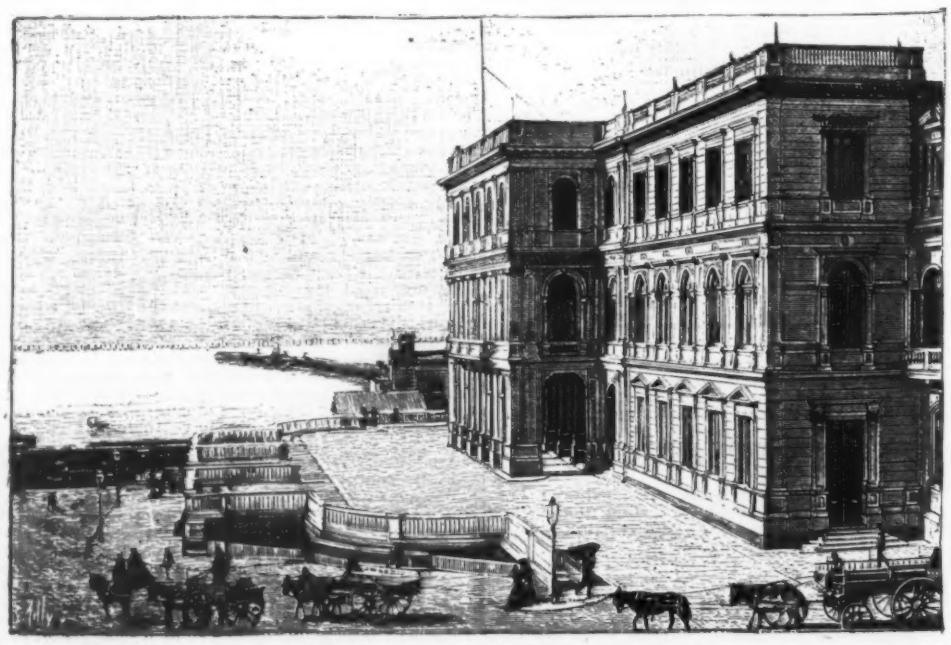
THE ARGENTINE REPUBLIC AND ITS PRESIDENT.

Dr. Carlos Pellegrini, now President of the Argentine Republic, is 43 years of age, son of an Italian or Savoyard architect who emigrated to Buenos Ayres in 1825, and who married an English woman. He was educated at the University, but joined the army of Buenos Ayres, allied with Brazil and Monte Video, in the war against Paraguay; after this military service he adopted the profession of an advocate, and practiced at the Bar with much success. Having been

CARLOS PELLEGRINI, PRESIDENT OF THE ARGENTINE REPUBLIC.

elected Deputy for the Province of Buenos Ayres, he made a figure in the Assembly, as a leading politician, and became Minister of the Interior shortly after the crisis in 1880, when Carlos Tejedor, Governor of the Province of Buenos Ayres, headed a revolution against the national government under President Nicholas Avelleneda, and was defeated in the battles of Coralles and Puente Alsina. As the result of that revolution Buenos Ayres became definitely the capital of the Argentine Republic, and General Roca was President from 1880 to 1886, in succession to Avelleneda. He was greatly assisted by Dr. Pellegrini in the needful measures of administrative reform, which were accompanied by large enterprises, the making of roads, railways, and canals, harbor and city improvements, commercial tariffs, and the negotiating of a foreign loan, managed by Dr. Pellegrini with remarkable success. He also established two political journals, the *Opinione* and the *Sud America*, of which he was the editor. Dr. Pellegrini was in Paris during the great exhibition of last year, as representative of the Argentine Republic, which had a special pavilion in the Champ de Mars.

Buenos Ayres, the capital of the Argentine Republic, is a city of South America, on the right bank of the Plata, which here, at a distance of 150 miles from the open sea, is thirty-six miles across. It stands in latitude 34° 36′ S., and longitude 58° 24′ W. Its disadvan-



THE GOVERNMENT HOUSE, BUENOS AYRES.

tages as a maritime town are great; the flood tides of the ocean, when backed by the easterly winds, being apt to make the estuary overflow its banks; and again, when westerly winds prevail, the estuary loses both width and depth. Monte Video, on the opposite shore, possesses a better harbor, and is nearer to the Atlantic, nor can it be doubted that, but for the greater facilities of Buenos Ayres in carrying on the inland trade, the former town would have proved a dangerous rival. Steam is rapidly placing both upon more equal terms. Of the trade, however, with Chili by Mendoza and the Andes—a trade which must always be carried on by land—Buenos Ayres must still command the monopoly. So familiar had Buenos Ayres become with land carriage on an extensive scale, that its merchants, when blockaded in front during the war with Brazil, established, as it were, a new port of entry in the mouth of the Salado or Saladillo, at a distance of at least 150 miles. As a city, Buenos Ayres labors under some peculiar disadvantages. Its immediate territory, purely alluvial, is almost as destitute of timber as of stones—the latter being brought either as ballast from Europe or as freight from Martin Garcia, an island on the opposite side of the estuary; and the former from the province of Entre Rios and from the isles of the Uruguay and the Parana.

Fuel is almost as scarce as building material—peach trees and the withered thistles of the prairies yielding the only indigenous supplies. Buenos Ayres, which appears to deserve its name of *good airs*, contains 250,000 inhabitants, about a third of whom are of European birth or descent. Among the Europeans the vast majority are Spanish, Italian, French, and British.

Buenos Ayres publishes newspapers in French, English, Italian and German, as well as in Spanish. The city is partitioned into blocks of about 150 yards square, by granite-paved streets. New houses are everywhere springing up; horse car lines traverse it in every direction, and it is brilliantly lighted by electricity; and the value of property has enormously increased. The principal buildings are the cathedral and its dependent churches, Episcopalian and Presbyterian chapels, a foundling hospital, an orphan asylum, the university, a military college, several public schools, and the government offices; there are also printing establishments, and manufactories of cigars, carpets, furniture, and boots and shoes. The exports consist of precious metals, hides, beef, wool, skins, tallow, and horse hair; and the imports of cottons, linens, woolens, jewelry, perfumery, and deals. There was a Continental Exhibition held at Buenos Ayres in 1882. Buenos Ayres was founded in 1535; but was subsequently twice destroyed by the Indians. In 1806, to the glory of Buenos Ayres, a British force which had just captured the city was obliged to surrender; and in 1807 another which attempted to recover the place was repulsed with heavy loss; and these successes over so formidable a foe emboldened the colonists, three years afterward, to throw off the yoke of Spain.

[FROM THE FARM JOURNAL.]

A CONNECTICUT PEACH ORCHARD.*

By J. H. HALE, South Glastonbury, Conn.

SIXTEEN THOUSAND BUSHELS OF PEACHES FROM THIRTY-FIVE ACRES.

IV.

ORDINARILY in a climate congenial to the peach it is expected that trees will begin to fruit in three years after planting. Here in New England, however, it is not well to expect any fruit till you get it. Everything may be lovely for 364 days in the year, when, if on the 365th day (or night either) the mercury drops to 18° or 20° below zero, you must hang your hopes on a willow tree—or at least on some other tree than the peach—for a year to come. There are but few varieties whose fruit buds can stand much more freezing than 12° to 15° below zero, and we are likely to get that here in Connecticut nearly every winter, and occasionally 20° below.

In speaking of the hardiness of fruit buds, I mean dormant ones on healthy, well ripened wood. Buds that have been swollen by warm days of early winter will not stand as much freezing. There is a vast difference in varieties as to hardiness. The Crawfords—early and late—have given us one light and one full crop in the past ten years, while Alexander, Smock and Hill's Chili produce good crops every year. Mountain Rose, Oldmixon, Stump, Keyport, Ward's Late and Stevens have given three full crops and two partial ones in the ten years.

Knowing somewhat of the tenderness of the Crawfords, when we began planting, we planted but a few of them, and, also, but a few of the other hardy varieties mentioned.

More than 80 per cent. of our trees are about equally divided between Mountain Rose, Oldmixon and Stump. Therefore, although we had over 6,000 trees planted previous to 1881, it was not till 1887 that we had any considerable crop of fruit. That year about one fourth of our trees started out for a full crop, and the rest promised more or less fruit. Those that blossomed full were very closely pruned by the shortening-in and thinning-out process, cutting away fully one half of the fruit that had started. Then early in July, when the fruit was three fourths of an inch or so in diameter, we commenced thinning by hand picking, leaving the best specimens not nearer than four inches apart, one from the other. To accomplish this on some 600 of the trees, we had to take off about four out of every five peaches that had set.

This thinning was a slow and somewhat costly undertaking, and some of the help on the farm, as well as the neighbors, thought we were "a little off" to "wait six years for a crop of peaches and then destroy it when half grown." So to please them and satisfy my own horticultural curiosity, a few of the full fruiting trees were left without thinning, with the result in the fall of about the same yield in baskets per tree from the unthinned as from those where four fifths of the fruit had been thrown away when green. However, the fruit of the latter was of such large size and superior color and flavor that it readily sold on the average for more than double that from the trees where all the fruit had been allowed to grow. I was well satisfied that every dollar invested in the work of thinning paid us a direct profit of at least five dollars. Aside from the fact that the trees were not exhausted one half as much as the others which had been obliged to produce such a great *number* of peaches to obtain an equal number of baskets of fruit. It is the reproductive power that saps the vitality of plant as well as animal life. The tree that produces four baskets of fruit, each basket containing 200 small peaches, each having a pit with the germ of life capable of producing another tree, will be exhausted of its vitality almost four times as much as the tree producing an equal number of baskets of peaches so large that fifty will fill the basket.

It is a well settled fact among all intelligent cultivators of the peach that it pays to thin the fruit in seasons of a full crop, although few practice what they know to be right. I am inclined to think that a man, to do the work as it ought to be done, wants his "bump of destructiveness" about as big as his whole head, and then he must "wade right in" as though he were going to strip the tree at once. The chances are, two to one, that he will then leave on more fruit than can be matured to the very best advantage.

V.

Having given years of study, hard work and thorough culture, as well as all the money we could make and borrow, together with years of patient waiting, to this peach venture, we had no intention of sacrificing this first good crop on the altar of ordinary methods of picking, marketing and selling. We therefore planned to practice Grange principles and "mind our own business." Having decided to use the full size half bushel round basket, we could find nothing in the market quite neat enough for fancy fruit. So, by paying an increased price of $20 per 1,000, we had a lot made up for us out of extra clean white poplar wood that made a very attractive package. In June, when it had become a settled fact that we were to have a fruit crop, I began to keep an eye open for vacant stores in the best business center of the city of Hartford, which is only eight miles from the farm.

Early in July a store every way suited for a wholesale fruit stand was found vacant. To make sure of it when wanted the last of August and through September, I leased it for three months. There were a number of chances to sublet it till it should be wanted for the fruit, but having always been a believer in judicious advertising, it was left vacant, and a big sign painted on cloth was strung across the front announcing "Headquarters for Hale's Connecticut Peaches after August 20," and smaller cards in the windows announced that "All fruit will be ripened on the tree and guaranteed sound when delivered to customers."

I then visited the leading cities and towns within 150 miles, except those on the south, and looked up the groceryman or fruit dealer who was catering to the best family trade of the place. In a good plain talk I told him just what prospects were ahead, that the fruit promised to be extra fine, would be carefully picked and assorted, packed according to grade, every basket labeled and warranted to be as represented, and that if he could handle it at *our prices* we would give him the exclusive sale for that town. As to the price, I said that would be 30 to 50 per cent. higher than Southern fruit; we should strive, however, to more than offset that in the *quality* of the fruit. Some "caught on" at once and made contracts, others promised to visit the orchards as soon as the fruit began to ripen and decide then, while some said they "Never yet saw a farmer that could or would pack goods straight, it, somehow, was so much easier to put the little ones in the bottom and the big ones on the top of the basket;" still they "might give us a trial order during the season." All in all, I was satisfied with the trip, and confident of being able to dispose of the fruit on my own terms.

For the transportation of fruit from the orchards to the city headquarters, wagons were built, low down, having platform springs on which were placed light frame bodies, 3 baskets wide and 13 long, holding 39 baskets on the bottom tier. The second or upper tier was made to extend out over the wheels on either side, so as to hold 5 baskets across and with 13 the long way of the wagon. This tier held 65 baskets. Thirteen three-quarter inch boards, one foot wide, laid across the wagon, made the floor for this tier and a covering for the lower one. A tight canvas covered the whole load.

Such wagons holding 104 half bushel baskets only two tiers high, made a low-down, easily handled load, that would show off to good advantage when uncovered, and as heavy as could well be handled over our roads by one pair of horses. We have since had made two wagons that carry 108 baskets, 36 on a tier, three tiers high, but do not like them nearly as well in any particular.

As to plans for picking. Our low-headed trees would allow of a man standing on the ground to gather two-thirds of the fruit. To get at the rest we made up out of light material a lot of steps 2½ feet high, broad enough on top to hold a picking basket and still leave room for a man to stand. When not used to climb upon, they were just the right height to hold the picking baskets of the men standing on the ground.

In addition to these we purchased two dozen step ladders of various sizes, from 5 to 9 feet high. However, it was seldom that we found use for any above 6 feet.

A shed for assorting and packing the fruit was built at a point most readily accessible from all parts of the orchard. In this were built tables or benches of the right height to stand at and assort the fruit.

For gathering the fruit we bought a lot of common half bushel market baskets with handles.

The limbs bending with their loads of almost ripening fruit, warned us that it would be impossible to drive among the trees with a wagon to gather the fruit up after the pickers. Therefore a common plank "drag" or "stone boat" was taken, a set of carriage springs bolted on top at each end, and on these was built a light frame or body large enough to hold 20 of the picking baskets. Experience proved this to be just the thing for one horse and a boy to gather up and haul in the fruit with.

Possibly, broad tired wheels not over 15 inches in diameter might make the draught lighter for the old horse, but otherwise I have not thought out any better plan than "the old boat" which has thus far served its purpose well.

Having planned to allow the fruit to mature on the trees, and then rush it to the consumers as quickly as possible, extra help was secured. When the first specimens began to ripen, all hands were taken two or three different afternoons and given a sort of picking drill, till each man was nearly always able to tell at sight a fully grown and just mellowing peach. No peach was allowed to be touched by the hand till it had been decided to pluck it. As a generous rivalry grew up among the men to see who should become the most expert judge, they were not long in understanding just what was wanted.

The heavy applications of potash that our trees had received caused all the fruit to take on a very high color on the sunny side when the fruit was scarcely two-thirds grown, so that in judging of maturity we could go nothing by that and had to look on the shady side or about the stem end of the peach for the greenish hue to turn to cream in the white-fleshed varieties, and a lemon yellow in the yellow ones.

As soon as the ripening was well under way, we began each morning, as soon as the dew was off, picking only the matured fruit from each tree. If the weather was very warm, all of the trees in any one variety were visited daily, otherwise only every other day, taking about 12 to 15 days to get all the fruit from any one tree. Of course the earlier and later pickings were light, as the bulk of the fruit would ripen in four or five days.

VI.

We had a number of bright, intelligent women, who had an eye for size and beauty and would handle the fruit more carefully than men, assorting all the good fruit into three grades. Peaches three inches or more in diameter, if sound and perfect in every way, made the highest grade, and as fast as found were packed in the shipping baskets assigned to them, and labeled "extra selected." The next lower grade, sound and perfect specimens 2 to 3 in. in diameter, went as "No. 1 selected." All other sound fruit, 1¼ to 2 in. in diameter, was labeled "selected seconds." Smaller and all irregular shaped specimens went as "culls," and bruised and slightly decayed as "specks."

The work of assorting and packing was very carefully done to prevent bruising. Baskets were all filled rounding full, the same grade ran all through each basket from top to bottom, and there was no topping off with larger or higher colored fruit. To see the top of any basket gave one an idea of just what the whole basket contained. On the side of each basket of the three first selected sizes were posted labels, red, for "extra;" white, for No. 1," and blue for "selected seconds." These labels were 4½ by 3 inches, and on them was printed our name and address, with guarantee of grade and quality of the fruit. The average through the season was about 50 per cent. of "No. 1," 22 of "extra," 23 of "No. 2," 3 of "culls," and 2 of "specks."

As soon as a load was ready, morning, noon, or night, it was at once started for the city store; a telephone message informing those there just what was coming.

A foreman was placed in charge of each orchard, and my brother acted as master of transportation and "general pusher" for all hands. I went to the city to do the selling, taking along two of my most able business assistants, also horse and delivery wagon, and two laborers in the city. Our home party obtained board right over the store, and so were right on the spot night and day. The beauty and size of the fruit, as well as its high quality, tempted buyers, in spite of themselves, and we soon got orders faster than we could supply them. Out-of-town parties, after the first lot, learned that the label and guarantee meant something and seldom visited the store, simply ordering by mail, telephone or telegraph just what they wanted, so many of each, "red," "white," or "blue." "Ten baskets white, white," meant ten baskets selected No. 1 white fruit; while "Ten baskets white, yellow," meant No. 1 yellow fruit. The highest grade fruit always sold first and at the very highest prices, and so on down through the various grades. The "culls" and "specks" sold to venders who could not afford to handle the choicer grades.

By our plan of allowing the fruit to come to maturity on the tree, some would drop to the ground each day and become more or less bruised and soiled. This was all gathered up daily, and a couple of boys and an old horse hired at $3 per day to peddle it out to families in our own and neighboring towns. Although always somewhat soiled, it being ripe and luscious and just right for immediate cutting up for table use, was in great demand at good prices, 60 cts. to $1 per basket. In this way everything was utilized and there was no waste. As to prices in the market, the "extras" sold for from $2.25 to $4, mostly from $2.50 to $3. A few of the "No. 1" sold for $2, while the most of them brought from $1.50 to $1.75. The "seconds" sold for from $1 to $1.35; while the "culls" and "specks" ranged anywhere from 15 cts. to $1, selling mostly at from 30 to 40 cts. The whole crop of some 5,000 baskets that season averaged $1.56 per basket.

Rent of store, telephones, extra expense of boarding help and horses in the city, and all expenses of marketing, besides allowing myself $5 per day, made the cost of selling a fraction over seven per cent.

In 1888 we had a crop of only about 1,000 baskets picked and assorted them in the same way, and sold all to one retailer at $1.60 per basket.

Last year the older orchards, as well as the 22 acre orchard planted in 1884, all produced a full crop, nearly 16,000 baskets in all. The management was the same as in 1887. A reputation had been made and the fruit sold daily, faster than it could be gathered. Commission men from New York and Boston, failing to secure consignments from us, came to buy, and were sadly disappointed that their tempting cash offers could not secure for them the whole output of the orchards. But having made our market and our friends, we proposed to hold the fort and have the fun all to ourselves.

Prices ranged about the same as in 1887, the average being $1.52 per basket. Only one loss was made, that of a bill of $36. I charged $10 per day for my time, was at considerable expense for livery hire, as I visited the orchards every other day, and yet the total cost of selling was only five per cent. while the commission men wanted 10 per cent., and I do not think could have

* Continued from SUPPLEMENT, No. 769, page 12298.

sold for as high prices as I did. All in all, there was a lot of satisfaction in attending to my own business.

The total cost of all orchards up to January 1st, 1890, had been slightly above $20,000. $35,167 worth of fruit had been sold from them, and there are still over 8,000 healthy trees living, of the 12,000 originally planted. The land has doubled in its productive capacity. Packing sheds, implements, wagons, baskets and ladders to the value of $4,500 are still with us. We think there is a chance yet for some fun and possibly profit in the years to come. There was a light bloom on all our trees the past spring, but it was cold and rainy all through May and most of the bloom was blasted, and 500 to 1,000 baskets is likely to be the limit of the crop this year. Nearly $2,000 worth of chemical manures were applied in April, and four horses have been kept at work harrowing and cultivating all the season thus far, so that expenses are counting up fast. Still, my experience thus far convinces me that one must spend considerable money on a peach orchard at the North if extra returns are expected.

Clark's Cutaway harrow, which has done such good work for us in the past, has been greatly improved this season by making it reversible. The old style with each revolution of the disks would throw the dirt outward from the center, and continuous culture tended to bank up the earth along the line of the tree rows. Now, with the reversible cutaway, the earth can be taken away just as well as it can be thrown up, and in orchards that require one plowing, the easiest, quickest, and safest way will be to plow back furrows up against each row of trees, and the summer's cultivation with the cutaway will level it all down. I am delighted with its work this season, as we keep two of the two-horse and one of the one-horse ones on the go most of the time.

After the very abundant crop of fruit last season, and with the increasing age of the trees, I had expected to note some considerable show of the yellows in the orchards this season; but now, near the beginning of July, only here and there can a trace be seen, possibly on a dozen trees in all. These have been doctored, and I do not expect many of them to die. In the older orchards, some trees have annually been broken by the winds, some by ice in winter, and still others by loads of fruit, while others have died from various causes, so that these orchards have lost their uniformity and beauty. Still, there are many fine, healthy trees left, with good prospects ahead. Closely planted and closely pruned trees have on the whole given us the best results; therefore, in planting a 20 acre orchard the past spring, we set the trees only 13 ft. apart each way. I intend to keep on planting a few trees each year; some I think may pay a profit, others do not. On the whole I rather expect to come out ahead, and yet I am inclined to think that if the same thought, labor and money we have invested in peaches had been devoted to Smith's cider, or Baldwin apples, the profits in twenty-five years would have been greater.

However, as I don't believe money is the main object to be sought for, I get a wonderful deal of satisfaction out of thinking that our experiment has demonstrated some facts in peach culture that ought to be of help to those who come after.

SMOKELESS POWDER—THE EXPLOSIVES OF THE PAST AND OF THE FUTURE.*

Before entering into the considerations of various orders raised by the adoption of the new military explosive, our first duty shall be to define clearly, once for all, what is now called a smokeless powder. Why smokeless? Would the weapons in which it is used—rifles, Hotchkiss guns or cannon—be, then, but simple pneumatic tubes analogous to the Zalinski gun, for example, maneuvered by the expansion of a compressed gas, and consequently emitting neither smoke nor noise of any sort? Not at all. Our present weapons remain in principle what they were yesterday; the charge of powder is ignited by the same methods; the noise produced by the rapid expansion of the gases upon their exit from the gun, and which could in no case be suppressed, remains as of old; the smoke alone has disappeared, or, more correctly speaking, has given way to a cloud of a tenuity that the old black powder had not habituated us to—to a bluish and transparent haze which wholly disappears a few seconds after the discharge of the gun.

And why is this smoke (for there is always smoke, whatever it be, just as there is always noise) colorless, why is it invisible, contrarily to what has been observed up to the present with the old powders? The reason of it is very simple, and is summed up in this remark: The explosion of the black powder produces in solid materials, outside of the gases themselves, about 50 per cent. of the total weight of the bodies set at liberty; while the explosion of the new powder gives simple gases only, without a mixture of solid substances of any sort.

That the explosion of common gunpowder is followed by the production of a thick cloud of smoke is a phenomenon that no one is ignorant of, and for which, up to the present, no sure remedy has been found. See, for example, with what weight it must weigh in the balance of our maritime wars, the order of which has been completely subverted by the advent of torpedo boats upon the marine stage!

Behold the little boat cleaving the waves and scarcely showing its grayish spine as it glides in the billows. The fire of the turrets is quickly turned upon it. Mitrailleuses and revolving guns to the front! The trouble is useless; the colossal armorclad is soon nothing more than a dismantled citadel surrounded by an insuperable cloud of smoke, by a swaddle of wadding that completely hides it from the assailant. Along with its precious and active gases, the explosion of the gunpowder has thrown an impenetrable fog into the atmosphere.

Let us explain, then. Let us take our gunpowder and decompose its combustion, as we shall presently do with the new powder. Chemically it may be represented by the following formula:

$$4KNO^3 + 5C + S = K^2SO^4 + K^2CO^3 + 5CO + 4N$$

Saltpeter, sulphur and carbon = { Sulphate and carbonate of potassa (solids), carbonic oxide and nitrogen (gaseous).

Aside from the simple gases, oxide of carbon and nitrogen, the combustion of black powder, then, gives a solid residuum composed in great part of sulphate and carbonate of potash.

A portion of this solid residuum deposits in the gun and constitutes the foulness of firearms; the rest is distributed, in a state of minute division, through the gases and vapors developed by the explosion, and, by darkening them, produces visible smoke. Soldiers and huntsmen, how many there are of you that scarcely suspect that the white and dense smoke which makes its exit like a plume from your weapon, after firing, is due to nothing but an incomplete combustion of the elements of the powder, nothing but a solid residuum suspended like a fine powder in the gaseous torrent that envelops and holds them after the manner of a light and invisible net!

Such a phenomenon could not occur with the new powder, the power of which, instead of being borrowed

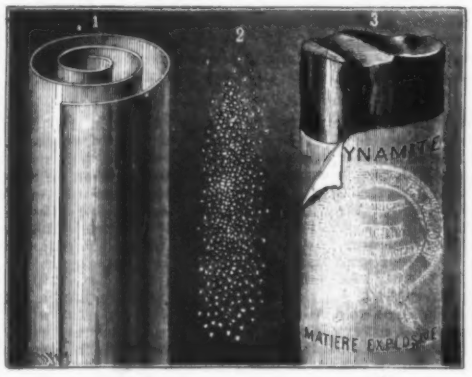


Fig. 1.—SMOKELESS POWDER AND EXPLOSIVE GELATINE.

1. Smokeless explosive in sheet form. 2. Grains of smokeless powder. 3. Explosive gelatine.

from the old ternary compound, is derived entirely from what we shall call the high explosives, and among them, especially, the nitrated celluloses and the nitroglycerines. Here, no more solid products in the explosion; gases, nothing but gases and vapors without dust to darken them—in short, an invisible, or at least a nearly invisible, smoke. As we have done for black powder, we must show the chemical equations that reproduce the mode of detonation of each of the high explosives just named.

The following is the equation of the decomposition of guncotton, which is nothing but a cellulose nitrated to a maximum:

$$C^6H^7(NO^3)^3O^5 = 2CO^2 + 4CO + 3H^2O + H + 3N$$

Guncotton = { Carbonic acid, carbonic oxide, water, hydrogen and nitrogen (all gaseous).

On the other hand, here we have the formula of the decomposition of nitroglycerine, which we shall presently find employed in the Nobel smokeless powder:

$$2C^3H^5(NO^3)^3O^4 = 6CO^2 + 5H^2O + 6N + 11O$$

Nitroglycerine = { Carbonic acid, water, nitrogen and oxygen (all gaseous).

We should be greatly deceived were we to believe that the scientists whose names are to be mentioned further along, and who have applied their studies to the finding of the true formula of the new powder, have undertaken the exclusive mission of finding a "smokeless" powder. They certainly were not ignorant of the fact that in directing their experiments upon explosives having a nitrated cellulose basis, this special property would necessarily follow; but this, however, was not what they specially cared for. What they were seeking before all was an explosive capable of giving the projectile a high initial velocity, without its breaking properties being capable, for all that, of endangering the security of the weapon—in a word, a powder of great velocity and feeble internal pressure, powerful without bursting characters. Finally, it was indispensable that such a powder should foul the weapon less than the old powder, lest the firing should lose all accuracy or even become impossible.

All the smokeless powders known up to the present have a nitrocellulose base, like those of which we have given the mode of decomposition above. It is impossible to enter here into the details of elementary chemistry upon the composition and preparation of the nitrocelluloses; on this subject our readers are free to consult treatises upon industrial chemistry. It will suffice to say that the nitrocelluloses, or nitrated celluloses which are obtained by the action of sulphuric and nitric acids upon cellulose, are generally divided into three classes, according to their degree of nitrification, the mono-, di- and tri-nitrocelluloses, according as one, two or three atoms of hydrogen have been replaced in the formula for cellulose ($C^6H^{10}O^5$) by one, two or three

Fig. 2.—COMBUSTION OF A STRIP OF SMOKELESS EXPLOSIVE.

atoms of azotyle or nitryle (NO^2), which would give our series of nitrated celluloses the following formulas:

Mononitrocelluloses	$C^6H^9(NO^2)O^4$
Dinitrocelluloses	$C^6H^8(NO^2)^2O^5$
Trinitrocelluloses	$C^6H^7(NO^2)^3O^5$

The mononitrocelluloses are imperfectly nitrated bodies; the trinitrocelluloses are guncottons, which are very inflammable, and the application of which to arms of war has, despite brilliant researches, given results that are as yet incomplete.

The dinitrocelluloses alone are to occupy us here, by the curious property that they possess of being soluble in certain mixtures—in a mixture, for example, of 2 parts of alcohol with 1 part of ether; while the trinitrocelluloses or guncottons are wholly insoluble in them. It can be foreseen now that smokeless powders must be obtained by the solution of a soluble cellulose in a volatile liquid, alone or mixed with accessory substances, oxidizing or retarding—the latter employed for rendering the explosion slower, and consequently diminishing the interior pressures that might lead to the bursting of the weapon.

Let us now refer to the accompanying engravings.

Let us examine Figs. 1 and 2. The former shows, as the legend teaches us, a sheet of smokeless explosive; the figure to the right (No. 2) reproduces the grains, or rather the small parallelopipedons of smokeless powder, ready to be placed, in the designated proportion, in the metal tube of the present cartridges. These grains, as may be conjectured, are cut at first in strips, and then into small bits, from the sheet (Fig. 1, No. 1), to which the operation of rolling has given a sufficient thickness. If we examine them carefully we shall find that they exhibit themselves under the form of a horny, scaly, semi-transparent material, slightly colored or even entirely brownish—an aspect, upon the whole, absolutely different from that of black powder. One might compare them to bits of tortoise shell or to celluloid cut into fragments.

Fig. 3.—THE NOBEL DYNAMITE WORKS.

1. Sulphuric acid factory. 2. Nitric acid factory. 3. Nitroglycerine works. 4. Dynamite works. 5. Smokeless powder works.

* Continued from Supplement, No. 756, page 12072.

It is simply our soluble nitrocellulose dissolved in a volatile liquid that has afterward been evaporated, leaving as a result of the operation a pasty, viscid, gummy mass, which can be drawn out, or rolled and laminated between two metal cylinders, as is done (all proportions and all temperatures preserved) with iron and steel plates in our large metallurgical works.

Smokeless powders have for nearly half a century been the object of the most able and subtile researches, occupying in turn the masters in the matter—the doctors of explosive sciences; in France, Vieille and our illustrious master Berthelot; in Austria, Von Lenk; in England, Abel; in Germany, Schultze; Johnson, and finally Alfred Nobel, the Swedish chemist who has been rendered celebrated by his studies upon dynamite and its derivatives. Mr. Nobel's smokeless powder, which we shall presently speak of again, is now, it

FIG. 4.—PROVING GROUNDS OF THE HAMM POWDER WORKS.

must be admitted, the only war explosive that can be seriously opposed to our national powder.

An examination of the various smokeless powders proposed in the course of recent years to the judgment of the military authorities of the different powers will thoroughly familarize us with the new explosive—the "explosive of the future," as we call it. These explosives, whatever they be, all have an invariable base—the nitrated celluloses, the explosion of which is entirely gasiform.

The first in data (after the Schultze powder, of course) is the powder patented in 1886 by Sir Frederick Abel, the eminent chemist of Woolwich, and containing 100 parts of nitrocellulose and ten to fifty parts of nitrate of ammonia. Always the nitrocellulose in the powder patented in 1888 by Mr. Turpin, the inventor of panclastite, and, it is said, of melinite. Nitrocelluose again in the smokeless powder manufactured since 1888 at the Belgian powder works of Wetterven; and again nitrocellulose in the powder of the Austrian works of Walsrode, called Wolf powder; and also in the Maxim powder, and in that of Johnson and Emmens, and finally in that of Nobel, adopted at present by the Italian army under the name of balistite.

Our intention has never been (our readers will understand, and it would, moreover, have been absolutely impossible for us) to describe the manufacture of the smokeless powder with which our French weapons are now charged. The Vieille powder is a State secret. Even did we know it, we should take good care not to reveal the least detail of it. All that it is allowable to say, all that we desire to know, and what we can assert, is that, as in all the powders whose nomenclature we have given, the properties of the French smokeless powder are due entirely, or at least for the most part, to the nitrated cellulose—soluble or insoluble—that it contains.

Although we are bound by the strictest caution as regards our national explosive, the same cannot be the case on the subject of the other smokeless powders, one of which especially, that of Nobel, is making itself talked about, and very loudly too, at this very moment. Our scientific curiosity, moreover, will be so much the more aroused in that, differing in this from all the other smokeless powders hitherto proposed, the powder of the Swedish chemist contains not only nitrocellulose, but also nitro-glycerine, in very large proportions.

If our readers will kindly refer to the formulas, to the equations of chemical decomposition that we have given above, showing the entire gaseiform explosibility of each of these two bodies, they will be convinced that we could not take a better example in support of what we are trying to demonstrate to them, the Nobel powder being, if we may so speak, doubly invisible, through the simultaneous presence, in its composition, of nitrocellulose and nitroglycerine.

It is now a long time ago that Mr. Nobel began to direct his studies upon mixtures of nitrocellulose and nitroglycerine. The explosive gelatines employed in public works and in mines for blasting rocks were the first and most interesting results of his experiments.

They are now objects of current use and manufacture. We give our readers herewith (Fig. 1, No. 3) a specimen of these gelatines, which have the gummy and gelatinous appearance and the color even of Mirabelle jelly. Our excellent draughtsman, Mr. Poyet, has very well rendered the texture and the external image of them, the only thing lacking being the amber color that adorns the treacherous and destructive substance.

These gelatines with a nitroglycerine and nitrocellulose base are truly the ancestors of the smokeless powder that Nobel is now experimenting with on the proving grounds of the European powers. If we refer, in fact, to the patent that the Swedish chemist took out in 1887, and which we have before us, we find that the inventor claims the ownership of a compound of 150 parts by weight of soluble nitrated cellulose, with a mixture of 100 parts of nitroglycerine and 10 to 12 per cent. of camphor. After stirring and laminating while warm, Nobel thus obtains a horny or semi-horny substance, which is easily cut into grains, and which, says he, presents the appreciable advantage of disengaging no visible smoke. Besides, its explosion is slow enough to allow it to be used as a powder for infantry or artillery purposes.

The Nobel powder, adopted by the Italian staff office, is manufactured on a large scale at the dynamite works which the Swedish chemist owns or in which he is interested at Avigliana, near Turin, Italy. The various phases of the manufacture, which is very ticklish, as may conceived, include operations that are simple in themselves: the mixing of the nitroglycerine and nitrocellulose, working up, laminating the gelatinous paste between steam-heated cylinders, cooling the sheets of different thicknesses thus obtained, cutting them into strips and then into grains, and passing the grains through sieves with apertures of less and less diameter.

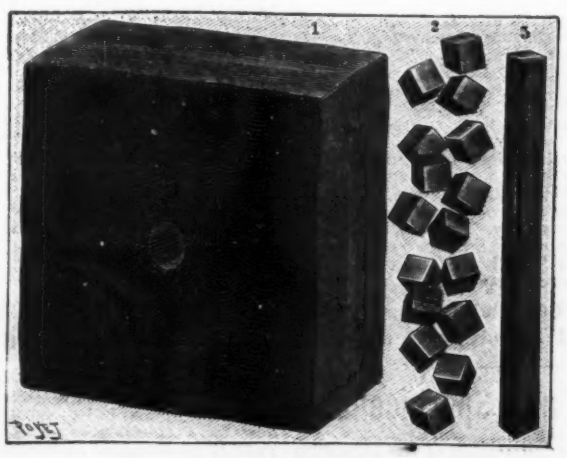


FIG. 5.—SPECIMENS OF NOBEL SMOKELESS POWDER.
(Actual size.)

All these operations, or at least the most important ones, are performed under water, in order to prevent heating and consequently fire.

Fig. 3 will permit our readers to get an idea of the general installation of the Nobel works. To the left the manufactory of sulphuric acid, to the right that of nitric acid, both necessary for the manufacture of nitroglycerine, the whitish roof of the manufactory of which emerges above the bastions that surround it. The nitroglycerine and nitrated cotton are afterward sent to the dynamite, explosive gelatine or smokeless powder works distributed within the inclosure of the works.

It still remains for us to touch upon the last side of the question—the side that is specially military, or rather tactical. To a new force of an importance as great as that of powder there should correspond, in fact, considerable changes in the order and progress of battles.

Summing up in a single celebrated expression that science, or rather prescience, that he alone of his time possessed, Napoleon scornfully said: "*On s'engage, et puis l'on voit.*" There are no more Napoleonic tactics with the smokeless powder, which allows you to see nothing or which shows you too much, which allows battalions to remain hidden in the thickets, without any sign to betray them, and which prohibits regiments from entering into the open field under the penalty of being immediately discovered. It is true that the great warrior asserted, under other circumstances, that tactics would have to be changed every ten years. Smokeless powder will have been the signal of one of these changes, of the greatest, perhaps, that military science has had to register, and, as some even say, of a true revolution.

The revolution that will have been made in the art of war through the application to arms of the new smokeless powder (of which we have given the principal, if not the complete history) will affect the weapons of the artillery as well as those of the infantry. Everything has already been said about the wonderful work realized in the firing of guns, both as regards the velocity given the projectile and the penetration—the irreproachable work of the new ball. As regards this, whether it concerns the Vieille powder, the Nobel powder, or any other similar explosive having a nitrocellulose basis, we are settled, at least relatively. Some 10 or 20 meters, more or less, of initial velocity; it is the affair of the learned experimenters of our maneuvering fields to decide upon the superiority of one or the other of the rival powders.

The special question of powders applicable to artillery pieces is not, however, as far as we have definite information, solved in an absolutely precise manner. The experiments still continue upon our European proving grounds, and scarcely a day passes that the news does not reach us of the results (more or less exact, perhaps, but with which we have to be content) of experimental firing.

These interesting experiments in the calculation of initial velocities, or of the velocity of the projectile upon leaving the muzzle of the weapon—gun or cannon—are made, as we know, by means of the electro-ballistic apparatus that *La Nature* has already described. Fig. 4 represents the arrangement of one of these apparatus at the time of some recent experiments made at the proving grounds of the Westphalian factory of Hamm, one of the large powder works that we mentioned in the course of our first article. In order to explain in a very summary way the general arrangement of the experiment represented in our engraving, it will suffice to recall the principle thereof. The projectile, on leaving the weapon, breaks a wire that closes the current of an electro-magnetic battery and sets the hand of a watch in motion. The impact of the ball upon the target, or upon the intermediate frames, closes the circuit, in turn, and stops the watch work, thus permitting of the reading of the exact time taken by the projectile to travel over the space between the gun and the target, and consequently of very accurately calculating its velocity.

The Vieille powder was thus recently tested at Creusot, and the Nobel powder at Essen, for the use of the artillery, with projectiles varying from 88 to 360 lb. and guns of 6 and 9 inches. Messrs. Schneider & Co. obtained initial velocities of about 2,600 feet per second, greater, therefore, by 490 feet than were obtained with the brown prismatic powders that we figured at the beginning of this study. The internal pressures in the chamber of the gun were, besides, perceptibly less than those that corresponded to the maximum velocity obtained with the same old prismatic powders.

To our great regret it has been impossible for us to procure (as we have been able to do with black powders) specimens of the smokeless gunpowder tried at Creusot. We, therefore, place before our readers' eyes a "grain" of the Nobel smokeless powder adopted, like the rifle powder of this same inventor, by the artillery of the Italian army. The engraving was made from the original, of actual size, as we have previously done with the explosives that we have passed in review. The grain perforated in the center, of Fig. 5, No. 1, measures about 24×22×4 inches, and weighs about 5 ounces. Its dark brown color and its external configuration are identical with those of the small grains of the same powder that we have already figured. Its chemical composition remains about the same. The initial velocities obtained at the Essen proving grounds with the Nobel powder varied between the limits of 2 620 and 2,800 ft. per second. The same results were obtained with powders in smaller grains (Fig. 5, No. 2), or in strips connected in bunches of ten or twelve (Fig. 5, No. 3). The reports of the experiments attributed, besides, to the Nobel powder a regularity of combustion and a homogeneousness of texture, say a want of porosity, which would maintain the firing in perfect conditions.

Having reached this point, it only remains for us to examine one more side of the question of smokeless powder, and this in truth is neither the least complex nor the least interesting one: we refer to the influence that the adoption of the new military explosive may and certainly must exert upon the fate of future battles. At the beginning of this hasty study, we spoke of the maneuvers executed at Champigny last March. Other experiments have quite recently been made on the field of Chalons in the presence of the Minister of War, and for the next great autumn maneuvers we are promised a genuine war, upon a small scale, executed for the first time with the new powder. What will be the outcome of these repeated experiments? What changes will they lead to in the organization of future contests? How will masses or units of troops have to perform hereafter in these hitherto unknown conditions of visibility and invisibility of combatants in the presence of each other?

The special chapter on the visibility of bodies of troops has alone formed the subject of numerous discussions, for the sole reason that it has called attention to the question, already old, of the color of uniforms. No more smoke, but the soldier exposed—the living

target against which perfectly adjusted balls are going to rain. And there has been recalled the legend of Napoleon traversing the battlefield of Wagram and stopping with pensive mien before the heaps of corpses of the soldiers whom, after the Austrian fashion, he had clad in white uniforms of excessive visibility. Was not the madder color of our foot soldiers' trousers also to mark their wearers hereafter for slaughter? From the very beginning of the trials of smokeless powder, these red trousers have been the object of great inquietude. Let us say at once that the patriotic fears raised by the red color are but imperfectly justified, for the simple reason that at a distance varying from 500 to 600 yards it cannot be distinguished any more than the other colors of the military uniform.

After the question of red trousers rose that of brilliant surfaces, the belt plates, the dazzling helmets of the cuirassiers or dragoons, the buttons, the gorgets, and the laces that it was proposed (and with more reason, it must be confessed) to render brown. The idea has occurred to Germany to blacken, and even to do away with, the legendary tip of her soldiers' helmets, but so far as we know, no protective measures have as yet been taken by our neighbors any more than by ourselves. It has been recently stated, in truth, that in the wake of the recent adoption of the new powder, the Austrian staff office has resolved to abandon the white uniform of its troops for a less visible gray one. The importance of the color of the uniform, no less than that of the retention or suppression of the shining surfaces of the military apparel, should not, however, be exaggerated. The adoption of a dark uniform, that certainly tends to be taken up by our neighbors, as well as by ourselves, might, on the contrary, be attended with consequences of exceptional gravity. A specialist of undisputed authority, General Tricoche, in a very interesting study relative to the influence of smokeless powder upon tactics, has called attention to the deplorable mistakes that the similarity of the uniform of our chasseurs to that of the German foot soldiers gave rise to at the time of the war of 1870–71. Marshal MacMahon likewise has recalled, under other circumstances, the sad slaughter of those same chasseurs of ours in the army of the Rhine, below Paris, upon the Loire, and in the East. Far from hiding and rendering the uniform dark, we should therefore be led to give the troops a national uniform, if not conspicuous, at least perfectly distinct from that of foreign armies.

Although the color of the uniform can reasonably be relegated to the background, the same cannot be the case with the great change that, in the new conditions of combat, modern tactics will certainly have to undergo. We cannot, however, as the author of the study above alluded to well remarks, lay down at present certain rules in this regard, for the sole reason that we need a datum of prime importance—battlefield experience. We can, however, already affirm that the disappearance of smoke will assure the artillery of a more and more preponderant place in battles. The cloud that extends in front of the batteries as soon as the first shots are fired is at once a drawback to accuracy in firing and a point of aim for the opposing artillery. This cloud no longer existing, we shall surely have more trouble to recognize the exact station of the enemy's guns; but this inconvenience will be largely compensated for by the incomparable advantage of "seeing well" all the points of the battlefield during an action, and this will facilitate both the regulation of the firing and the changes of objectives.

The artillery will thus acquire a considerable role. Its murderous projectiles will go raking the different points of the ground in succession, with fearful precision, and its power will have no other check than that of the opposing artillery. Victory, then, there is no doubt (according to the opinion of competent men) will remain with those who have been able to assure themselves of a priority in regulating, and consequently of a superiority in firing in the battle.

It is upon the judgment of the former director of our artillery that we shall close a study that, despite the secret that still surrounds the history of smokeless powder, we have endeavored to render as complete and sincere as possible. The inevitable contest which, in a few years perhaps, is to bathe the old world in blood (and the last one, let us hope) will take upon itself the task of verifying our previsions, and of teaching us what will become of tactics, and, with them, the physiognomy of future battlefields.

The arsenals of "civilized" nations are daily accumulating, in fearful piles, shells, canister shot, and cartridges ready for the next hecatomb. The first blast of the clarion will have scarcely sounded when melinite and smokeless powder, roburite, gun cotton, and picrates—the entire martial and bloody lyre—breaking the silence to which they are condemned, will start off to decide the fate of arms and of peoples.—*M. Helene, in La Nature.*

PROF. DE VOLSON WOOD ON "CONSTITUTION OF CELESTIAL SPACE."*

The writer of this article criticises and denounces some opinions expressed by Hirn in a recently published work on the above subject. Hirn, he says, holds that if "celestial space" is a "*plenum*," the "ether" which "fills it" is not a material substance. In protest to this view, the writer advances instead that ether is a grade of matter of finer atomic structure than gross matter, while another writer in the Supplement says that the element atoms of chemistry are fabrics of these finer atoms—that is to say, of ether or protyle microns—and that in this way there is no plenum in space at all. If Hirn's "plenum" is immaterial it is, however, not a plenum but a vacuum, and the opinion given in his work, which is criticised, can have no other simple purport than this statement, that *the plenum of celestial space is a vacuum.* Certainly Hirn is right in asserting this; and certainly Prof. De Volson Wood is quite right also in saying that there is neither a plenum nor a vacuum in celestial space.

There is in the space every imaginable grade of orbs, bodies, atoms, and microns without bounds or limitations, but the question of mutual comportments of these many-graded "ions" to each other is one of *matter's waging work* in space and time, in manners which have to be learned by experience; but in this *cordon* of work accomplishments there is, besides matter, another equally objective agent, *energy*, engaged and active, whose place in space and time Prof. De Volson Wood's "micron" hypothesis of ether and protyle takes no account of, while Hirn's contention really is that in matter particles' wardourship of space and time, we leave out half the rank and file—all the hoplites of *energy*, that is to say—which are really also acting. One phalanx (the material one) of space's and time's "occupants" is doing the "static," and the other (the cortège of *energy's* emissaries) is doing the dynamic part of the world's work. They are like infantry and cavalry in an army of assault or occupation.

We have learned from thermodynamics that heat is a kind of physical agency of which no mechanical explanation can be given; and Hirn's contention is that we can give no mechanical explanation, either, of *how* matter and energy *in combination* occupy space and time with their ranks and files *together*. Hirn says that this is *as unrational a theme* of logical discussion as the assertion itself is, that "*the plenum of celestial space is a vacuum.*"

But by putting the real difficulty in this plain language (which Prof. De Volson Wood himself eschews, and censures him for openly pronouncing), Hirn really points out distinctly a great truth in physics, not less notable and momentous for its coming future progress than the one "sung about" by Lucretius, that *not only matter* (which Hirn and De Volson Wood are both equally agreed about), but also *time* and *space* and *energy* are all just alike particled and atomic, and all take part *pari passu* with each other in the world's work by throbbing operations, which, like those of the piston head in a steam engine, are *not* unbrokenly *continuous* actions, but *all of them*, in *essence, thermodynamic cycles.* A. G. H.

Slough, August 10, 1890.

* Scientific American Supplement, No. 744, p. 11893.

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